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THE PHILIPPINE

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AND THE INDUSTRIES

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THE LEATHER INDUSTRY OF THE PHILIPPINE ISLANDS[1]

By VICENTE Q. GANA

(From the Laboratory of General, Inorganic, and Physical Chemistry, Bureau of Science, Manila, P. I.)

TWO PLATES

There exists in the Philippine Islands a considerable, but very primitive, tanning industry. The methods now in use have not undergone substantial modification since they were introduced by the Chinese, probably several centuries ago. Consequently the leather produced is inferior in quality, especially so since tanning in a tropical country involves difficulties not encountered elsewhere. There is no obstacle to a great expansion of this industry. The leather market is good, and additional supplies of the necessary materials can be had in considerable quantities and at fairly reasonable prices. Therefore, in order to stimulate the industry, an extensive study of the existing industry and some practical experiments using improved methods have been carried on.

Data regarding the leather industry furnished by the provincial treasurers are given in Table I.

TABLE I.—*Number and output of tanneries of the Philippine Islands.*

Locality.	Tanneries.	Tanned hides produced.	Locality.	Tanneries.	Tanned hides produced.
Manila	8	39,050	Tayabas	2	250
Bulacan	11	36,000	Batangas	19	220
Iloilo	3	5,929	Zamboanga	1	216
Cebu	4	4,401	Nueva Ecija	4	164
Pangasinan	11	2,600	Sorsogon	1	120
Albay	4	1,320	Antique	2	70
Ilocos Sur	37	1,130	Cavite	4	65
Ilocos Norte	13	1,114	Cagayan	17	54
Ambos Camarines	3	270	Capiz	22	22
Rizal	1	250	Total	167	93,245

[1] Received for publication May 10, 1915. This paper is being issued in Spanish.

Although doubtless lacking great accuracy, the statistics show that the tanning industry produces leather to the value of from 1,500,000 to 1,800,000 pesos [2] per annum. On the whole, the figures regarding production are believed to be too low.

THE LOCAL LEATHER MARKET

There is a large and increasing local demand for leather and leather goods which is met almost entirely by importation. Table II shows the Philippine customs invoice value of imports of leather and manufactures thereof for several years.

TABLE II.—*Invoice value of imports of leather.*

Year.	Pesos.	Year.	Pesos.
1903	1,373,572	1909	988,276
1904	985,070	1910	1,520,926
1905	986,334	1911	1,988,382
1906	922,440	1912	2,051,614
1907	958,268	1913	2,380,246
1908	1,343,924		

The actual value of these goods is unquestionably several times larger than the invoice value given in the table. A gradual increase has occurred in almost every item included in these figures. Most notable, however, is the increase in the importation of boots and shoes. The introduction of European customs of dress may safely be expected to maintain or accelerate this rate of increase for several years. Table III gives the classification of the leather and manufactures thereof imported during the years 1912 and 1913, as shown by the annual reports of the Collector of Customs. It will be noted that the item boots and shoes constitutes nearly 60 per cent of the total.

TABLE III.—*Classification and value of Philippine imports of leather and manufactures thereof for the fiscal years 1912 and 1913.*

	1912	1913
	Pesos.	*Pesos.*
Boots and shoes	1,173,904	1,390,864
Sole leather	102,524	200,016
Upper leather	109,886	256,534
All other	519,920	253,758
Belting	65,662	59,862
Harness and saddles	79,718	163,594
Pocketbooks, purses, wallets, and hand bags		55,618
Total	2,051,614	2,380,246

[2] One peso Philippine currency equals 100 centavos, equals 50 cents United States currency.

In recent years a number of boot and shoe factories have begun to operate in Manila and they are still expanding. As they consume imported sole and upper leather exclusively, the demand for satisfactory grades of these goods is likely to increase very markedly. It is to these classes of leather that the prospective tanner in the Philippines should devote his first and main attention.

In addition to the industry just mentioned, which uses imported leather and which is conducted by Europeans and Americans, there is an even larger leather-working business among the Filipinos and Chinese. It is carried on in small shops or as a household industry. Its products include cheap shoes, sandals, harness, saddles, bags, etc., made almost exclusively of leather tanned in the Islands. The improvement of domestic leather would, of course, be of great advantage to these industries.

The present prices of staple leathers on the local market are approximately as follows:

TABLE IV.—*Prices of staple leathers on the Manila market.*

Article.	Per piece.	Per kilogram.
	Pesos.	*Pesos.*
Domestic, tanned, native cattle hides	13-20	[a] 1.40-1.80
Domestic, tanned, Australian cattle hides	16-24	[a] 1.60-1.90
Imported sole leather	[a] 40-50	2.00

[a] Calculated from actual market prices and the average weight of hides.

Quality considered, native leather commands a much better price per kilogram than imported. This arises from the Filipino custom of buying leather by area rather than weight. The loss to the Filipino tanner in producing undertanned leather is very apparent in the prices per piece. There is no exportation of leather or leather goods from the Philippines.

RAW HIDE SUPPLY

In spite of the inroads which rinderpest has made upon the cattle-raising industry of the Philippines and of the strict limitations placed in recent years on the importation of animals from abroad, with the consequent shortage on the local market, very many hides and skins go to waste each year.

There has been difficulty in getting reliable information about the supply of hides and skins from domestically slaughtered animals, but from figures of the Bureau of Agriculture it appears that 11,133 sheep, 69,851 goats, 1,019 horses, 36,935

cattle, and 17,890 carabaos were slaughtered in the Philippines during the calendar year 1913. These animals would furnish roughly 90,000 skins and 56,000 heavy hides. The number of available raw hides, according to the reports of the treasurers of the several provinces mentioned in Table I, is 54,057.

Hides and skins are bought and sold by the piece. At market centers salted hides of Australian cattle average about 16 pesos and of native or Chinese cattle about 10 pesos. This amounts to about 65 centavos per kilogram for the former and 60 centavos per kilogram for the latter. However, in many provinces cattle hides can be bought as low as 1 peso per piece and average less than 5 pesos. They are frequently not removed from the animals. There is a small production of dried hides which are exported to Hongkong and British East Indies for the manufacture of glue. Table V gives the value of such exports.

TABLE V.—*Exports of dried hides from the Philippine Islands to Hongkong and British East Indies.*

Year.	Pesos.	Year.	Pesos.
1907	30,336	1911	22,626
1908	25,710	1912	22,626
1909	27,920	1913	29,492
1910	46,074		

Very little care is exercised in the method of preserving hides for the market. Systematic salting is not in general use, and many hides reach the tanner in a semiputrid condition. The process of salting hides is a very simple one and consists in the even distribution of salt, about 25 kilograms for every hundred kilograms of hides, over the flesh side of the hides in a layer so thick that solid salt always remains. The hides should be stacked in such a way that the draining away of any resulting brine will be prevented. Hides which are salted with reasonable care keep very well, even in this climate.

In addition to the domestic product, there has been a considerable importation of raw hides and skins into the Philippines during the last four or five years. The imported hides come almost exclusively from China. Table VI gives the figures of the importation of raw hides and skins.

TABLE VI.—*Value of imports of raw hides into the Philippine Islands.*

Year.	Pesos.	Year.	Pesos.
1907	9,056	1911	36,210
1908	19,906	1912	151,222
1909	[a] 39,326	1913	62,428
1910	[b] 76,772		

[a] From China. [b] Mostly from China.

The weights and prices of these imported hides are given in Table VII.

TABLE VII.—*Weights and market prices of raw salted hides in Manila.*

Variety.	Weight.	Price per hide.
	Kilograms.	*Pesos.*
Australian cattle hides	20-25	13-16
Chinese cattle hides	15-21	7-12
Carabao hides	18-35	6-8
Native cattle hides	15-30	5-15

TANNING MATERIALS

The only tanning materials used in the Philippines are the barks of the various species of mangrove (Rhizophoraceae or mangrove family) and the camanchile tree (*Pithecolobium dulce* Benth.). The former are very plentiful and cheap, selling for about 25 pesos per metric ton. In spite of this fact and in spite of their high tannin content, mangrove barks are not extensively used in the Philippines outside of the city of Manila. This is primarily because of the resulting harshness and dark red color of leather tanned with mangrove alone. However, good light-colored leathers can be produced by combining camanchile and mangrove, as I have demonstrated by experiments which will be discussed later. The mangrove barks have been considerably studied[3] and are widely used in Europe and America. Their use may well be extended in the Philippines.

Camanchile bark is used almost exclusively by Filipino tanners, who prefer it on account of the light-colored leather it produces. Because of this demand the price of air-dried camanchile bark has risen as high as 10 pesos per 100 kilograms. The tree is widely scattered throughout the Islands, although nowhere systematically or extensively grown. The present annual consumption of bark amounts to about 1,500 tons. Exhaustion of the supply is threatened, as the trees are commonly killed by too extensive stripping of the bark. The bark is brownish gray and rough outside and reddish brown inside. It produces dull but light-colored leather, which reddens on exposure to light. An infusion of it contains a tannin of the catechol class, which

[3] Bacon and Gana, *This Journal, Sec. A* (1909), 4, 205; Williams, R. R., ibid. (1911), 6, 45. The waste wood can be utilized for firewood [Cox, Alvin J., ibid. (1911), 6, 1], or for destructive distillation, as shown by experiments now under way.

gives a green-black precipitate with iron salts, a light brown precipitate with bromine water, and crimson line when in contact with one drop of concentrated sulphuric acid. Upon analysis a representative sample of the bark gave the following results, calculated on water-free material: Total extract, 34.77 per cent; nontannin, 9.41 per cent; tannin, 25.36 per cent.

Camanchile bark infusion soon ferments and decomposes in this climate, resulting in the destruction of tannins, the development of a disagreeable odor, and a thickening of the liquid due to a viscous gelatinous formation which accumulates and grows on the surface. A few experiments with phenol as a preservative showed that a concentration of 0.01 per cent does not check the fermentation appreciably, as in a control infusion the tannins were destroyed, the color became a deep wine red—at least three times as intense as the original red orange—a somewhat penetrating smell was given off, and a gelatinous formation and a slimy sediment developed, which made the infusion viscous. After four months the loss of tannin amounted to 15 per cent of the total tannin content. An infusion containing 0.1 per cent phenol at the end of the same period showed a practically unaltered tannin content and an acidity equal to 0.0714 gram acetic acid per 100 cubic centimeters. A little fermentation which soon ceased had produced some slimy sedimentation, but had not altered the appearance or odor of the clear supernatant infusion.

Camanchile bark contains irritating principles, which are believed by laborers in the tanneries to indicate roughly the strength of infusions. Infection of the eyes, producing weakening of the sight, and irritation and swelling of the lids are attributed to them.

Through the coöperation of Dr. Fred W. Foxworthy, of the College of Forestry at Los Baños, who collected and sent me the material, I was enabled to examine several barks and fruits which have not as yet been used as tanning materials. The results are presented in Table VIII.

Of these tanning materials none seems particularly promising, either on account of the insufficient supply or on account of the low tannin content.

THE FILIPINO PROCESS OF TANNING

As has been stated previously, the Filipino process of tanning is very primitive and produces a very inferior grade of leather. It was desired to make a study of this process in order to point out its prime defects and to suggest improvements which might be put into effect without materially increasing the investment

TABLE VIII.—*Analyses of miscellaneous tanning materials.*

Sample No.	Material.	Botanical name.	Distribution.	Precipitate with ferric salts.	Precipitate with bromine water.	Color on contact with concentrated sulphuric acid.	Moisture.	Tannin.	Non-tans.	Character of leather produced.
							Pr. ct.	*Pr. ct.*	*Pr. ct.*	
1	Cateban bark	*Quercus* sp	Scattered in hilly districts.	Blue-black	Brown	Red-brown	10.2	10.9	4.2	Rather hard; hazelnut brown.
2	Ulayan bark	do	do	do	do	do	10.2	11.0	3.9	Satisfactory texture; hazelnut brown.
3	Balinghasay bark	*Buchanania arborescens.*	Scattered generally.	Green-black	do	Deep brown	8.7	8.2	7.6	Hard and somewhat harsh; dark reddish brown.
4	Pagsahinging bark.	*Canarium villosum.*	Common in hilly districts.	do	Yellowish brown.	Pink	8.0	2.8	5.5	Thin and soft; pale brown.
5	Calamansanay bark.	*Nauclea calycina*	Scattered in hills	do	Brown	Brown	8.8	6.5	7.6	Thin; very dark red.
6	Ligas bark[a]	*Semicarpus accuminatissima.*	Scattered generally.	do	Yellowish brown.	Pink	8.0	2.2	4.3	Thick; reddish brown.
7	Sacat fruit	*Terminalia nitens*	do	do	Light brown	Reddish brown	8.9	19.8	16.3	Thin, smooth grain; dark color.

[a] The sap of this tree produces blisters on the skin.

in equipment or supplies. For this purpose the tanning industry as conducted at Meycauayan, Bulacan, was chosen for study. Meycauayan is one of the largest leather-manufacturing centers in the Philippines, and its methods are fairly representative of those of the Islands as a whole. Eleven tanneries are located there, with an aggregate output of 36,000 pieces per year, consisting almost wholly of cattle hides. These include practically the entire product of the Government slaughterhouse at Sisiman and an almost equal number of imported hides from Hongkong. A few carabao hides are tanned, but the Filipino tanners are not willing to attempt the tanning of these hides except under exceptional circumstances. On account of their thickness they are very hard to tan and they are liable to putrefaction. Therefore they are usually split, and very commonly only the grain side is tanned, the remainder being discarded or used for glue.

The leather produced by the Filipino process is soft and pliable and, in general, is very much undertanned. It is characterized by an unpleasant odor, especially when wet. This leather lacks the firmness and durability desirable in sole leather and, at the same time, is too thick for first-class upper leather.

The salted hides, as received at Meycauayan, are usually in good condition, not showing evidences of decay or having particularly offensive odors. They are laid in packs of from 17 to 20 and are soaked for about eight hours in water in the bed of a river. They are then removed to lime pits of masonry construction, which are usually placed, in a series of from 10 to 20, in the open air without protection from sun or rain. The usual dimensions of a pit are 1.7 meters by 0.9 meter, with a depth of 0.8 meter. A pack of 20 hides is laid in the pit, 25 liters of lime and sufficient water nearly to fill the pit being used for the liming process. The water used is taken either from the river or from shallow surface wells near by.

The method of preparing the lime liquors and laying the hides in the liming pits is as follows: The lime is mixed with water, and the gravel and the coarser particles are removed with a bamboo sieve. A hide is laid in this liquor, folded lengthwise with the hair outside. Other hides are placed on top in the same manner, until the pack is complete. The hides are left in the lime pits for from ten to fifteen days, during which time they are overhauled three or four times. At each overhauling the order of laying is reversed, so that the upper hide in the pack is laid at the bottom, and so on. The exact duration of the liming process is determined by the loosening of the hair and the degree of plumping of the skin. Frequently after the

hides have been removed from the lime pits and have been fleshed and dehaired, they are again returned to the lime liquors if the tanner believes more plumping is desirable. The lime liquors are used only once.

The limed hides are taken to the river and depilated, fleshed, and cleaned by scraping the hide with a blunt knife to take out as much lime as possible (Plate II, fig 1). They are left in the river under water for a few hours to be freed from lime and are then ready for the tan pits. Except the hair, all the fleshings and scrapings and even parts of the pelt itself go to the refuse basket. All this waste is mixed with the lime and pressed into cakes, dried in the sun, and sold for 9 pesos a picul[4] to glue makers. This return is customarily divided into one half for the tanner and the other half for the laborers.

The tan pits, partly above the surface of the ground, under cover of a large, open shed, are walled up with adobe stone[5] and ordinary mortar. Each pit measures 1.9 meters by 1 meter with a depth of 1.2 meters and holds 20 native or Chinese cattle hides or 17 Australian hides. For each such pack a tan bark infusion is prepared by placing from 500 to 600 kilograms of chopped camanchile bark in the tan pit and macerating it for three days with about 1,200 liters of a liquid consisting of two thirds fresh water from a surface well and one third old, used tan liquor. A date for making the infusion is so chosen that the dressed hides will be ready for the tan pits on the fourth day. The bark is then removed and used for laying between the hides.

In laying away the pack, the workman places a hide smoothly grain side up, so that about half its surface rests on a layer of bark in the bottom of the pit. Another layer of bark is spread over this surface, and the other half of the hide, which has in the meantime been supported in the hands, is folded along the middle of the back down upon the bark. After another layer of bark has been placed over this hide, the remainder of the pack follows in the same manner, and the whole of the bark infusion is added. The pack is handled and the hides are kneaded with bare feet four times during tannage, usually once on each of the first four days. After each handling the hides are returned to the pit as before. Sometimes a fifth handling and kneading or even a sixth is resorted to when necessary to prevent putrefaction.

The object of kneading is to compress and distort the hide

[4] One picul is equivalent to 63.25 kilograms.

[5] Porous volcanic tuff.

fiber and to hasten the absorption of the tannin. Such is the effect of kneading that the hides are almost half "struck" by the fourth day. They are then laid away in the tan pits for six weeks to complete the tannage. After this, if they are not to be sent to market immediately, they are laid in pits, called *tingalan,* with old, exhausted tan liquor. Sometimes they are left here for years. When required, they are taken to the river, thoroughly washed and cleaned, stretched on sticks, and exposed to direct sunlight. When dry, they are sent directly to the market without further treatment.

DEFECTS OF THE FILIPINO PROCESS

The process outlined above is very inefficient in many respects. In a study of the process the following defects proved to be among the most significant:

1. The putrefaction of the hides during the process with consequent loss of hide substance.
2. Waste in tanning materials.
3. Undertannage of the product.
4. Imperfect drying and finishing.

Of these defects by far the most important is that of putrefaction. During the rainy season this is especially difficult for the tanner to prevent, and it is commonly the custom to shut down the tanneries almost completely during that period. The decay is evidenced by a very disagreeable odor which not only develops in the leather itself, but which also pervades the entire tannery and becomes almost suffocating. Skins in which putrefaction occurs tan on both exterior surfaces, while the interior of the hide liquefies. The pelt commonly splits into grain and flesh sheets. The Filipino tanners attribute the putrefaction to dilute tan liquors, which they believe are caused by the use of barks collected during the rainy season. Usually the putrefaction occurs most markedly during the first days of tannage, and at this stage soft, gray spots, which frequently suppurate, may develop. Such spots do not tan at all, and, of course, the entire skin is ruined thereby. Aside from this ruining of the skins by putrefaction, a less extensive decay prevents proper plumping and swelling of the hides and consequent proper absorption of tannin. For this reason it is almost impossible for Filipino tanners to tan thick hides.

The Filipino tanners endeavor to control this putrefaction by adding large quantities of fresh bark to the tan pits and by more frequent kneading of the hides. This procedure, however, is

very ineffective, especially so since the tanner often fails to detect decay until it has proceeded beyond remedy.

The obvious measures to be taken to prevent this difficulty consist simply in greater cleanliness during the entire process. Tan pits, handling floors, and the like should be frequently cleaned and disinfected. Water free from pollution or unusual amounts of mineral matter is also a necessity. The river, on which the tanneries of Meycauayan are located, flows into Manila Bay and is subject to tidal variation. It is, therefore, decidedly brackish and falls far short of what is to be desired in a water for this purpose. Table IX presents an analysis of this water.

TABLE IX.—*Analysis of Meycauayan River water.*

[Numbers represent parts per million.]

Physical characters	brownish yellow with salt taste
Reaction	alkaline
Total solids	52,672.0
Appearance on ignition	blackening and evolution of hydrochloric acid
Free or saline ammonia	0.37
Organic or albuminoid ammonia	0.68
Oxygen consumed	50.00
Chlorine	26,284.4
Equivalent to common salt	43,313.7
Nitrogen as nitrates	trace
Nitrogen as nitrites	nil
Silica (SiO_2)	25.6
Oxides of iron and aluminium (practically all Al).	21.0
Oxide of calcium (CaO)	809.0
Oxide of magnesium (MgO)	2,909.3
Sulphuric anhydride (SO_3)	2,706.7
Total hardness:	8,663.7
Permanent	8,571.2
Temporary	92.5
Bicarbonic acid radical (HCO_3)	142.1
Carbonic acid radical (CO_3)	nil
Free carbon dioxide (CO_2)	4.4

Aside from the large amount of mineral matter present, this water is also objectionable on account of the large quantities of putrefying organic matter ordinarily found in it. A loop of water invariably produced liquefaction in serum and gelatin tubes within forty-eight hours' incubation at ordinary temperature.

Table X gives the analysis of a typical sample of water from

surface wells in this locality such as are used for making up tan liquors.

TABLE X.—*Analysis of water from a surface well at Meycauayan.*

[Numbers represent parts per million.]

Physical character	normal
Reaction	neutral
Total solids	946.0
Appearance on ignition	evolution of hydrochloric acid
Free or saline ammonia	0.048
Organic or albuminoid ammonia	0.068
Clorine	203.6
Nitrogen as nitrates	trace
Nitrogen as nitrites	0.016
Silica (SiO_2)	39.7
Oxides of iron and aluminium (largely Al).	48.0
Oxides of calcium (CaO)	165.0
Oxides of magnesium (MgO)	20.6
Sulphuric anhydride (SO_3)	41.1
Bicarbonic acid radical (HCO_3)	179.2
Free carbon dioxide (CO_2)	13.2
Total hardness:	486.6
Permanent	351.0
Temporary	135.6

Analyses of the liquors used at various stages of the process show very clearly the progress of putrefaction and loss of hide substance. The lime used is made by burning sea shells; it has a total alkalinity equivalent to about 70 per cent calcium hydroxide. An analysis of a typical lime liquor, after removal of the hides, is shown in Table XI.

TABLE XI.—*Lime liquor from a Filipino tannery after removal of the hides.*

	Grams per 100 cubic centimeters.
Nitrogen as ammonia	0.0457
Equivalent hide substance	0.266
Total hide substance	0.987
Unchanged hide substance	0.721

These figures show that nearly 8 kilograms of dissolved hide substance are lost from each pack of twenty hides weighing approximately 230 kilograms, which is equivalent to about 3.5 per cent of the weight of the hides.

Fresh lime liquors about 2 days old are almost sterile, but easily become contaminated by the surface drainage. When 1 week old a loopful of lime liquor will liquefy gelatin within six

days' incubation at ordinary temperature. The lime liquors invariably have a strong ammoniacal odor after two days in contact with hides.

A piece of green pelt from a tannery, weighing about 2 kilograms after dehairing and fleshing, was kept in 2 per cent aqueous solution of phenol. On the fourth day the hide substance dissolved in the liquid was found to be 2.66 grams, or 0.133 per cent of the wet pelt. The phenol solution was changed for a fresh one which, after nineteen days, gave but a faint precipitation ring with a tan infusion. This same phenol solution, after four and a half months in contact with the hide, gave a much stronger precipitation ring, which must be due, not to any further decomposition, but probably to the outward diffusion of dissolved hide substance previously developed inside of the pelt. There cannot have been any putrefaction in the phenol solution, as demonstrated by pieces of the same pelts which remained unaltered in acid and alkaline bouillon tubes for nearly six months. This soluble hide substance is the product of bacterial activity in the pelt.[6]

Pelt which had been limed, fleshed, and dehaired by the usual process of the Filipino tanner, after being kept for one month in 2 per cent phenol solution, gave on analysis the results included in Table XII.

TABLE XII.—*Analysis of limed, fleshed, and dehaired pelt.*

Substance.	Calculated on the basis of green pelt.	Calculated to a water-free basis.
	Per cent.	*Per cent.*
Water	71.50	
Nitrogen	4.23	17.3
Equivalent hide substance	27.70	97.2
Lime etc.	0.80	2.8

The liquefying bacterial conditions of the tannery liquors have been determined by means of serum and gelatin media tubes. These tubes were inoculated with one loopful of the tannery liquor and incubated at ordinary temperature—about 30° C. The time period required for the liquefaction of the media is noted in Table XIII.

[6] Brunton and MacFadyen, *Proc. Roy. Soc. London* (1890), 46, 542–53.

TABLE XIII.—*Liquefaction of the media due to liquefying bacteria at a Filipino tannery.*

Description of sample.	Days to liquefy with one loopful of sample.	
	Serum.	Gelatin.
River water used for washing hides	2	
Do		2
Do		2
Lime liquor 2 days old	7	
Do		20
Lime liquor 1 week old		6
Native tan liquor 1 month old	2	
Native tan liquor		2
Do		2
Native tan liquor, strong from covered pit		8
Fresh tan liquor		8
Artesian-well water as delivered at tannery		15
Suspender liquor (my experiment) mixed with 10 per cent native tan liquor		3
Do		6
Liquor from layer No. 1 (my experiment) [a]	3	
Do	13	
Liquor from layer No. 1 (my experiment), from covered pit		15
Fresh tan liquor made with artesian water	10	

[a] In this case the workmen were allowed to contaminate the liquor by wading in it with bare feet still wet with liquors from poluted vats, according to the usual practice. Contrast the three days required to liquefy the serum with the following experiment where thirteen days were required. The only difference is that in the second case I insisted that the workmen first wash their feet in clean water before entering the vats.

The data demonstrate that the tan liquors of the Filipino process generally contain abundant putrefying or liquefying bacteria. Even in the case of pelts that had been washed in 0.5 per cent phenol baths, liquefaction ensued within forty-eight hours when immersed in such liquors. The smell of the leather and tan liquors is due to this putrefaction.

Infusions of fresh camanchile tan bark in pure water are generally practically devoid of liquefying bacteria, as liquefaction of inoculated serum and gelatin media occurs only after from forty-two to seventy-five days of incubation. However, the infusion of this tan bark is quite neutral in its action toward liquefying bacteria. It does not kill them. On the other hand, bacteria do not grow in it except when there is enough proper nourishment present in the form of other suitable substances. In the latter case the multiplication and activity are great in a warm climate.

The tannins, like common salt, do not destroy bacteria, but check the putrefaction of hide substance. Common salt prevents

the putrefaction by extracting water from the hide, while the tannins convert the hide into imputrescible leather. The work of the salt is transient, while that of the tannins is permanent.

An experiment was performed to determine the resistance to, and growth of, liquefying bacteria in camanchile bark infusion at a temperature between 27° and 32° C. Tan infusions were inoculated with tannery liquors, and subsequently a loopful of each was transferred to serum and gelatin media tubes. The periods of time required for liquefaction are given in Table XIV.

TABLE XIV.—*Effect of tan infusions on liquefying bacteria.*

Liquor tested.	Days to liquefy.			
	Serum.		Gelatin.	
	Incipient liquefaction.	Complete.	Incipient liquefaction.	Complete.
Fresh control infusion		42		
Control infusion 1 day old			23	26
Control infusion 3 days old			[a]	[a]
Infusion 1 day after inoculation with river water	5	15		
Do			1	8
Infusion 3 days after inoculation with river water	4	10		
Do			10	14
Infusion 6 days after inoculation with river water	5	11		
Do		10		
Infusion 1 day after inoculation with native tan liquor	4	6		
Do	5	6		
Infusion 8 days after inoculation with native tan liquor	3	4		
Do			10	12
Infusion 3 days after inoculation with native tan liquor	4	10		
Infusion 6 days after inoculation with native tan liquor			4	10
Layer liquor No. 1 (my experiment)				3
Do	4	9		

[a] No liquefaction in seventy-five days.

In this experiment the gelatin tubes were more resistant to the action of the liquefying bacteria than the serum tubes, thus illustrating the fact which must always be borne in mind by a tanner that blood remaining in the hides and skins is one of the causes of speedy putrefaction. Even with fresh and strong tan infusion liquefying and other bacteria will thrive and are sure to do mischief provided there is enough proper food for them.

The waste of tanning material is due almost solely to the Filipino practice of chopping rather than grinding the bark. As the price of camanchile bark is steadily rising and constitutes an item of very large expense to the tanner, any methods for

more effective utilization of the material would be very practical. Tan bark is never ground, but chopped with a heavy, curved knife into pieces about 3 by 4 centimeters in size, which are much too large to permit complete extraction of the tannin. This practice results in a large waste of material, as may be seen from determinations included in Table XV.

TABLE XV.—*Analyses of fresh and "spent" camanchile bark.*

Condition of bark.	Moisture.	On dry basis.		
		Total extract.	Nontannins.	Tannins.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	10.34	34.77	9.41	25.36
Used	12.64	23.63	8.31	15.32

In this case only 39.6 per cent of the total tannins contained in the bark was used by the tanners, while the remaining 60.4 per cent was thrown away in the "spent" bark.

Undertannage of leather is one of the chief causes of an unsatisfactory product. This is produced in part by insufficient plumping of the hides, in part by the use of coarse bark in making infusions, but principally because of false economy in the use of the bark. In examining the tan liquors in any Filipino tannery, it will be noted that they are uniformly much too weak, except at the very beginning of the process. In fact, the first tan liquors, corresponding to suspender liquors, are the strongest which are used in the process. This, of course, produces rapid tanning of the surface and, to a great extent, prevents thorough tanning of the interior of the hide.

In determining the percentage of tannin in the tan liquors, specific gravity tests were found to be very unreliable, especially in the case of the older liquors. Large quantities of mineral matter are introduced from the brackish river water and from the hides themselves which are insufficiently delimed. Deliming is rarely effective, as is clearly indicated by the red coloration produced when a drop of a phenolphthalein solution is placed on the surface of the hide.

A piece of delimed hide just ready for the tan pits, after being placed in river water with sufficient formaldehyde to preserve it, was found to be still well impregnated with lime after forty-eight hours. The specific gravity of the river water itself is 1.029. Table XVI shows the specific gravities of tan liquors at various stages of the process.

TABLE XVI.—*Specific gravities of Filipino tan liquors.*

Sample No.	Age.	Contact with pelts.	Specific gravity.
	Days.	*Days.*	
1	5	1	1.022
2	4		1.022
3	6		1.022
4	8	5	1.021
5	3		1.011
6	6		1.016
7	8	5	1.019

Analyses of tan liquors are given in Table XVII.

TABLE XVII.—*Analyses of Filipino tan liquors.*

Sample No.	Stage of process.	Specific gravity.	Acidity as grams acetic acid per 100 cc.	Grams per 100 cc. of the liquor.				
				Ash.	Organic matter.	Suspended matter.	Nontans.	Tannin.
1	First day	1.010	0.15	0.79	1.59	0.33	1.39	0.61
2	Fourteenth day	1.018	0.09	2.22	1.64	0.47	3.30	(a)
3	Sixth week	1.018	0.17	1.64	2.41	1.41	2.59	(a)
4	Third day, 20 per cent extra strength.	1.022	0.06	2.03	1.86	(b)	3.22	0.67
5	Half completed	1.019					3.20	0.34

[a] Trace. [b] Undetermined.

The tannin in these liquors is strikingly low, and the nontans, especially the mineral matter, are very high, as is to be expected when brackish water is used. The analyses of the ash of Filipino tan liquors is given in Table XVIII.

TABLE XVIII.—*Analyses of the ash of Filipino tan liquors.*

[Grams per 100 cc. of liquor.]

Sample No. [a]	Silica (SiO_2).	Oxides of iron and aluminium (Fe_2O_3 Al_2O_3).	Oxide of iron (Fe_2O_3).	Calcium oxide (CaO).	Magnesium oxide (MgO).	Sulphuric anhydride (SO_3).	Chloride and carbonate of sodium plus phosphoric anhydride.
1	0.006	0.026		0.061	0.034	0.039	0.62
2	0.009		0.131	0.093	0.145	0.064	1.77
3	0.030	0.089		0.133	0.102	0.074	1.21
4	0.008	0.039		0.135	0.167	0.078	1.60

[a] The samples correspond to the tan liquors in the previous table.

TABLE XVI.—*Specific gravities of Filipino tan liquors.*

Sample No.	Age.	Contact with pelts.	Specific gravity.
	Days.	*Days.*	
1	5	1	1.022
2	4		1.022
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4	8	5	1.021
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				Ash.	Organic matter.	Suspended matter.	Nontans.	Tannin.
1	First day	1.010	0.15	0.79	1.59	0.38	1.39	0.61
2	Fourteenth day	1.018	0.09	2.22	1.64	0.47	3.30	(a)
3	Sixth week	1.018	0.17	1.64	2.41	1.41	2.59	(a)
4	Third day, 20 per cent extra strength.	1.022	0.06	2.03	1.86	(b)	3.22	0.67
5	Half completed	1.019					3.20	0.34

[a] Trace. [b] Undetermined.

The tannin in these liquors is strikingly low, and the nontans, especially the mineral matter, are very high, as is to be expected when brackish water is used. The analyses of the ash of Filipino tan liquors is given in Table XVIII.

TABLE XVIII.—*Analyses of the ash of Filipino tan liquors.*

[Grams per 100 cc. of liquor.]

Sample No. [a]	Silica (SiO_2).	Oxides of iron and aluminium (Fe_2O_3 Al_2O_3).	Oxide of iron (Fe_2O_3).	Calcium oxide (CaO).	Magnesium oxide (MgO).	Sulphuric anhydride (SO_3).	Chloride and carbonate of sodium plus phosphoric anhydride.
1	0.006	0.026		0.061	0.034	0.039	0.62
2	0.009		0.131	0.093	0.145	0.064	1.77
3	0.030	0.089		0.133	0.102	0.074	1.21
4	0.008	0.039		0.135	0.167	0.078	1.60

[a] The samples correspond to the tan liquors in the previous table.

In addition to the mineral matter the organic nontans are in considerable part nitrogenous materials. The quantity of nitrogenous materials in representative tan liquors is shown in Table XIX.

TABLE XIX.—*Nitrogen content of Filipino tan liquors.*

[Grams per 100 cc. of the liquors.]

Sample No.	Nitrogen as saline ammonia.	Equivalent hide substance.	Total nitrogen.	Equivalent hide substance.
1	0.0430	0.234	0.062	0.343
3	0.0405	0.223	0.077	0.422
5	0.0980	0.540	0.137	0.754

Tests show that extract of camanchile bark contains considerable quantities of nitrogenous material, and a correction must, therefore, be made. Table XX gives the nitrogen contents of the samples in the preceding table and of a fresh camanchile bark infusion calculated as hide substance in per cent of total solids.

TABLE XX.—*Nitrogen contents of Filipino tan liquors calculated as percentage of total solids.*

Sample No.	Saline ammonia as hide substance.	Total nitrogen as hide substance.	Organic nitrogen as hide substance.
1	11.70	17.17	5.47
3	8.45	15.99	7.54
5	15.20	21.38	6.18
Fresh	1.74	6.60	4.86

DEMONSTRATION OF SIMPLE, EFFICIENT IMPROVEMENTS IN THE FILIPINO TANNING PROCESS

Bearing in mind the facts that Filipino tanners do not possess sufficient capital to purchase expensive equipment and that they are indisposed to abandon completely the methods they have used for generations and the cheap labor which they can obtain, an endeavor was made to find simple, inexpensive methods of improvement. In the main this was accomplished without serious difficulty. The improvements in the process are very striking, although no doubt they could be still further increased, especially by additional modification of equipment. The follow-

ing method was put into effect in a Filipino tannery which was then operating under the old methods. This was done as an object lesson, in spite of the unfavorable circumstances which it was anticipated would be encountered. A leather resulted which was odorless, firm, and entirely satisfactory as a sole leather. For this purpose nine hides were chosen as indicated in Table XXI.

TABLE XXI.—*Hides used in tanning experiment.*

	Kilos.
Australian cattle hide:	
No. 1	16.5
No. 2	23.5
No. 3	24.0
Chinese cattle hide:	
No. 1	19.0
No. 2	16.0
No. 3	19.0
No. 4	21.5
No. 5	18.5
No. 6[a]	25.5

[a] Carabao.

The hides were washed in fresh, clean water supplied from a near-by artesian well. The washing was repeated five times and, together with soaking, required seven hours.

TABLE XXII.—*Analysis of the artesian-well water.*

[Numbers represent parts per million.]

Physical characters	normal
Reaction	alkaline
Total solids	274.0
Appearance on ignition	little blackening
Free or saline ammonia	0.074
Organic or albuminoid ammonia	0.026
Chlorine	4.8
Nitrogen as nitrates	nil
Nitrogen as nitrites	nil
Silica (SiO_2)	45.0
Oxides of iron and aluminium	trace
Oxide of calcium (CaO)	6.0
Oxide of magnesium (MgO)	little
Sulphuric anhydride (SO_3)	trace
Total hardness:	10.7
Permanent	10.7
Bicarbonic acid radical (HCO_3)	183.0
Carbonic acid radical (CO_3)	15.0

This water is almost sterile as it comes from the well and was very little contamined in carrying to the tannery. The hides were next placed in a pit with 40 liters of lime and 400 liters of artesian water, and were left for eight days, during which time they were handled five times.[7] They were then fleshed and dehaired and placed in a 1 per cent phenol solution for twenty-four hours. A bath in a 0.2 per cent solution of sulphuric acid for fifteen minutes followed, for the purpose of neutralizing the surface lime of the pelts. They were placed in a suspender containing very weak, fresh tan liquor, with a specific gravity of about 1.000 at ordinary temperature, and whose strength and acidity were increased every day during ten days up to 1.004 specific gravity and 0.2 per cent acetic acid.

After ten days in the suspender liquor the hides were removed and laid in another clean pit with 50 kilograms of half-used tan bark and sufficient tan liquor of specific gravity 1.006 to cover the hides. On the fourth day they were handled, and 50 kilograms of fresh bark were added. On the ninth day they were again handled, with an addition of 100 kilograms of fresh tan bark. On the twenty-fifth day they were again handled, with an addition of 130 kilograms of fresh bark; on the forty-fifth day with 210 kilograms, and on the sixty-fourth day with 162 kilograms. The specific gravity of the liquors was taken after each handling.

TABLE XXIII.—*Specific gravity of handled liquors.*

Handling No.	Specific gravity of tan liquor.
1	1.006
2	1.006
3	1.007
4	1.012
5	1.017
6	1.020
7	1.022

While in the suspenders and during the first forty-five days in the laying pit the rate of tannage was rapid. Thereafter it decreased markedly, as is shown in Table XXIV.

The rate of tannage of the carabao hide is noticeably slower than that of the cattle hides on account of its thickness. Such thick hides should consequently always be tanned separately.

[7] The only advisable changes in the Filipino method of liming would be to use from one to three changes of lime liquor and to keep the lime pit clean.

TABLE XXIV.—*Analysis of leather samples taken at different times during tannage, after the twenty-fifth day in the laying pit.*

Day.	Kind of hide.	Moisture.	Parts per 100 of H_2O free material.	
			Hide substance.	Tanning matters and ash.
		Per cent.		
Twenty-fifth	Cattle	17.3	58.7	41.3
Forty-fifth	do	16.9	51.0	49.0
Sixty-fourth	do	14.5	50.8	[a]49.2
Seventy-second	do	14.1	50.1	49.9
Do	Carabao	14.2	53.1	46.9

[a] The owner of the tannery at this point unfortunately added 5 fresh pelts to the pit, thereby reducing the strength of the tan liquor and the degree of tannage.

The increase in strength of the tan liquors, as indicated in Table XXIV, was by no means as rapid as was to be desired. However, as no means were available for grinding the bark, it was not feasible to avoid this objectionable feature. In addition, the process was considerably disturbed by the real or fancied necessities of the owner, who used tan liquor from the layer pit for other hides.

On the seventy-second day the goods were taken from the pit, piled upon a beam to drain, brushed, wiped, and lightly oiled on the grain. When half-dried under the shed, where they hang from one to five days according to weather conditions, they were laid in a pile to temper. This allows the moisture to distribute itself equally throughout the hides. They were then struck out with a striking pin to smooth and flatten the grain and were hung under the shed further to dry. A second striking followed. They were then rolled with a smooth, hardwood roller provided with a suitable carriage and properly weighted, first with a light weight and a slightly moist grain, and then with a heavy weight and a nearly dry grain. After being rolled, the goods were dried rapidly with free circulation of air and finally polished with a brush by hand.

The hides so obtained were free from all of the principal defects of the native leather. They displayed no odor nor evidence of putrefaction at any point. The loss of hide substance was much smaller and the degree of tannage much higher, as indicated by Table XXV, which shows the weight of the native leather and that produced by the improved process.

TABLE XXV.—*Weights of tanned hides.*

Weights of Filipino tanned hides.		Weights of leather from hides tanned in this experiment.[a]	
Australian cattle leather.	Chinese cattle leather.	Australian cattle leather.	Chinese cattle leather.
Kilo.	*Kilo.*	*Kilo.*	*Kilo.*
11.5	9.0	11.5	13.0
10.0	10.0	17.0	11.0
12.5	9.0	16.5	13.0
11.0	10.5	----------	14.0
10.5	9.0	----------	12.0
12.0	10.0	----------	20.0
10.5	9.0	----------	----------
13.0	10.0	----------	----------

[a] These hides are arranged in the same order as in the list of raw hides above in Table XXI.

The average weight of hides tanned by the improved process is approximately 32 per cent greater than that of those ordinarily produced. In other words, the Filipino tanner obtains about 3 kilograms of leather from 6 kilograms of green pelt, while by the improved process this yield of leather is increased to about 4 kilograms of higher grade product. Table XXVI shows the degree of tannage in native leathers as compared with those produced by the improved process.

TABLE XXVI.—*Chemical analysis of leather.*

	Moisture.	Parts per 100 of water-free material.	
		Hide substance.	Tanning matters and ash.
	Per cent.		
Improved product	14.1	50.1	49.9
Filipino product	16.5	61.4	38.6
Do	16.3	62.9	37.1

The color and grain of the hides produced by the improved process, while not perfect, were entirely satisfactory for local market conditions, and the actual increase in the value of the goods by these improvements far exceeded the small increased cost of putting them into effect. Local tanners were alarmed by the large quantities of tan bark which were added to the laying pit. It was difficult for them to realize that no tannin is wasted,

but that the use of old tan liquor, suitably diluted, is to be preferred for fresh hides, so that the entire excess of tannin is eventually utilized. The only actual increase in cost lies in the added labor in finishing the leather. For this expenditure the tanner will be amply repaid. Finally, the practice of chopping bark by hand cannot be too severely condemned as wasteful of tanning material and labor alike. A mill for grinding the bark would repay its entire cost in a few weeks of operation.

An experiment with ten hides was carried out substantially as above outlined, except that mangrove bark was used exclusively in the layer pits after lying in suspender liquor of camanchile. The resulting leather was orange brown, which is not objectionable. The texture was firmer than that of camanchile leather. The partial substitution of mangrove for camanchile is to be recommended as rapidly as the local leather buyers can be induced to accept slightly darker colored goods.

SUMMARY

1. The tanning industry in the Philippine Islands amounts to about 1,800,000 pesos per annum and can be greatly extended.
2. It has been shown that improvements can be put into effect in a Filipino tannery without modification of the equipment and with little increase in expense, which will yield about 32 per cent more leather of a higher grade than that now produced. Leather produced by the improved process is firm, of a satisfactory color and grain, and free from the disagreeable odor or evidence of putrefaction and other principal defects of native leather.
3. A great economy in both labor and material can be effected in the Filipino process by grinding the tan bark in a mill instead of chopping it by hand. The tanning materials never become satisfactorily extracted from chopped bark, and the resulting waste is very great.
4. Good, moderately colored leathers can be produced by combining camanchile and mangrove at a considerably decreased cost.

ILLUSTRATIONS

Fig. 1. Liming pits.

Fig. 2. Chopping tan bark.

Fig. 3. Tanning vats.

PLATE I.

Fig. 1. Dehairing and fleshing at the river.

Fig. 2. Drying finished leather.

PLATE II.

SALT INDUSTRY AND RESOURCES OF THE PHILIPPINE ISLANDS [1]

By ALVIN J. COX and T. DAR JUAN

(From the Laboratory of General, Inorganic, and Physical Chemistry, Bureau of Science, Manila, P. I.)

SEVENTEEN PLATES AND 5 TEXT FIGURES

The beginning of the salt industry in the Philippines is obscure. As long as the Islands have been inhabited it is probable that every family along the sea border was its own salt maker. The salt was probably largely obtained by boiling and was an inferior article, as no method was adopted to separate the lime, the salts of the mother liquor, and other impurities. It is impossible to determine just when the first attempt at commercial salt making was made in the Archipelago. Reference is made to it as an ocupation as early as 1583.

Miguel de Loarca in that year wrote of Macagua Island as follows:

> The people are poor and wretched possessing nothing but salt and fish.[2]

Of Lutuya Islets he said, "The chief occupation in all of these islets is making salt and mats," and of Similara Island and the small islands toward Mindoro, "All the people of these islets gather a very scanty harvest; they make salt and are traders."[3]

In 1637, in connection with the commerce of the Orient, which the Dutch carried on with Batan, mention is made of the profit to the island from salt.[4]

In accounts of the successful attack of the Spaniards against the Moro pirates and on Jolo in 1731 we read that the conquerors also ravaged Talobo and Capual Islands and destroyed the salt works there from which the Moros derived much wealth.[5]

In 1687, in a narrative of the Augustinians in the Philippines, Diaz[6] writes of the unprecedented rains which ruined the crops and caused a great scarcity of provisions. He said:

> it was impossible to work the salt-beds, the price of salt rose so high

[1] Received for publication February 10, 1915.

[2] Blair and Robertson, The Philippine Islands. The Arthur H. Clark Company, Cleveland (1903), 5, 53.

[3] Ibid. (1903), 5, 73.

[4] Ibid. (1905), 27, 93.

[5] Ibid. (1907), 46, 39.

[6] Ibid. (1906), 42, 258.

that it came to be worth twelve pesos[7] for half a fanega [½ (55.501 liters)], although its ordinary price was two or three reals [25 to 37.5 centavos]—and some years even less, depending on the (height of the) water and on the heat of the sun, on which conditions this so necessary industry depends.

These and other letters tell of the production of salt at an early date in many parts of the Islands. During the following years mention is made by many writers of the barter of salt and other articles of food on the one hand, and gold on the other, between those who lived along the coast and the inhabitants of the mountains.

All processes for salt making fall into three groups, depending on the character of the heat employed and the manner of its application: (1) Use of solar heat, or solar salt manufacture; (2) direct artificial heat, or kettle and pan processes; (3) steam heat, or grainer methods.[8] The majority of the plants in the Philippine Islands belong to the first group; there are a few in the second, and none in the last group.

USE OF SOLAR HEAT IN DIFFERENT PROCESSES

In warm climates, as upon the shores of the Mediterranean, the coast of California and Mexico, the entire Pacific coast of South America, the islands of the West Indies, Southern Australia, and the whole coast line of tropical Asia, including China and Japan, sodium chloride is obtained by the evaporation of sea water in the shallow lagoons or in shallow basins or pools, constructed upon the seashore and exposed to the sun's rays.

France is one of the most important sea-salt-producing countries of Europe. The total area covered by the salt works is about 19,000 hectares, in 12 departments—7 on the Mediterranean and 5 on the Atlantic coast. In this industry some 8,000 laborers are employed for several months every year.[9]

Portugal, Spain, and Italy are also among the chief sea-salt-producing countries of Europe.

Italy is the cradle of the saltern industry. Pliny relates that Ancus Martius, the fourth of the early kings of Rome, who reigned from 640 to 616 before Christ, was the first who had sea water led into closed basins to evaporate for salt. Later many such salterns were established, so that even in very early times the manufacture of sea salt was an important industry. An interesting relic of this is the Via Salaria—the salt road—one

[7] One peso Philippine currency equals 100 centavos, equals 50 cents United States currency.

[8] *7th Annual Rept. U. S. Geol. Survey* (1886), 505.

[9] Furer, Salzbergbau (1900), 269; *Bull. La. Geol. Surv.* (1907), 7, 158.

of the oldest of Roman roads, which was built to accommodate the salt trade.[10]

China is one of the oldest salt-producing countries of the Orient. In former times the salt trade in China was so highly esteemed that at the annual opening of the salt works princes were present in person and took an active interest in the first salt boiling.[11]

In many of these countries the production of salt is a state monopoly, or is under government control. The salterns, or salt farms, are either leased to private companies, or are administered directly by the officials of the government. A good example of this is China, where taxation of salt commenced as far back as the seventh century before Christ. It is said that the great Emperor Yu, 2205 to 2197 before Christ, ordered Chingchou Province to supply the court, among other things, with salt. During the Chow dynasty, 1122 to 249 before Christ, officers were appointed for the administration of salt matters. At the present time the revenue derived from salt is the Chinese Government security for the reorganization loan of 25,000,000 pounds sterling.[12]

Since American occupation all restrictions on the manufacture of salt in the Philippines have been withdrawn.

Solar evaporation must be carried on in general where it is hot and where evaporation greatly exceeds the rainfall—that is, where there is a pronounced dry season. Fig. 1 shows that there are two definite and different types of rainfall in the Philippines. The eastern half of the Archipelago has a rainfall more or less equitably distributed throughout the year; hence the principal salt works are confined to the western portion of the Islands, where there is a definite dry season.[13]

The degree of difference in the two types is shown in figs. 2 and 3, where the mean of the values [14] for the two groups is graphically represented. The normal evaporation from 1885 to 1907 for Manila is also shown in fig. 4.

[10] *Bull. La. Geol. Surv.* (1907), 7, 168.

[11] *Far East. Rev.* (1912), 9, 295.

[12] Ibid. (1912), 9, 295.

[13] The differentiation of rainfall into the eastern and western types may not be complete; for example, there is but one weather station in Mindoro, and while it and probably the remainder of the low portions of the island fall in with the western type, it is believed that the rainfall in the high mountains is very heavy, due to the fact that the narrow neck of Luzon in Tayabas allows the rain clouds to pass over and precipitation to take place in the high altitudes of Mindoro.

[14] Cox, Alvin J., *This Journal, Sec. A* (1911), 6, 288–91.

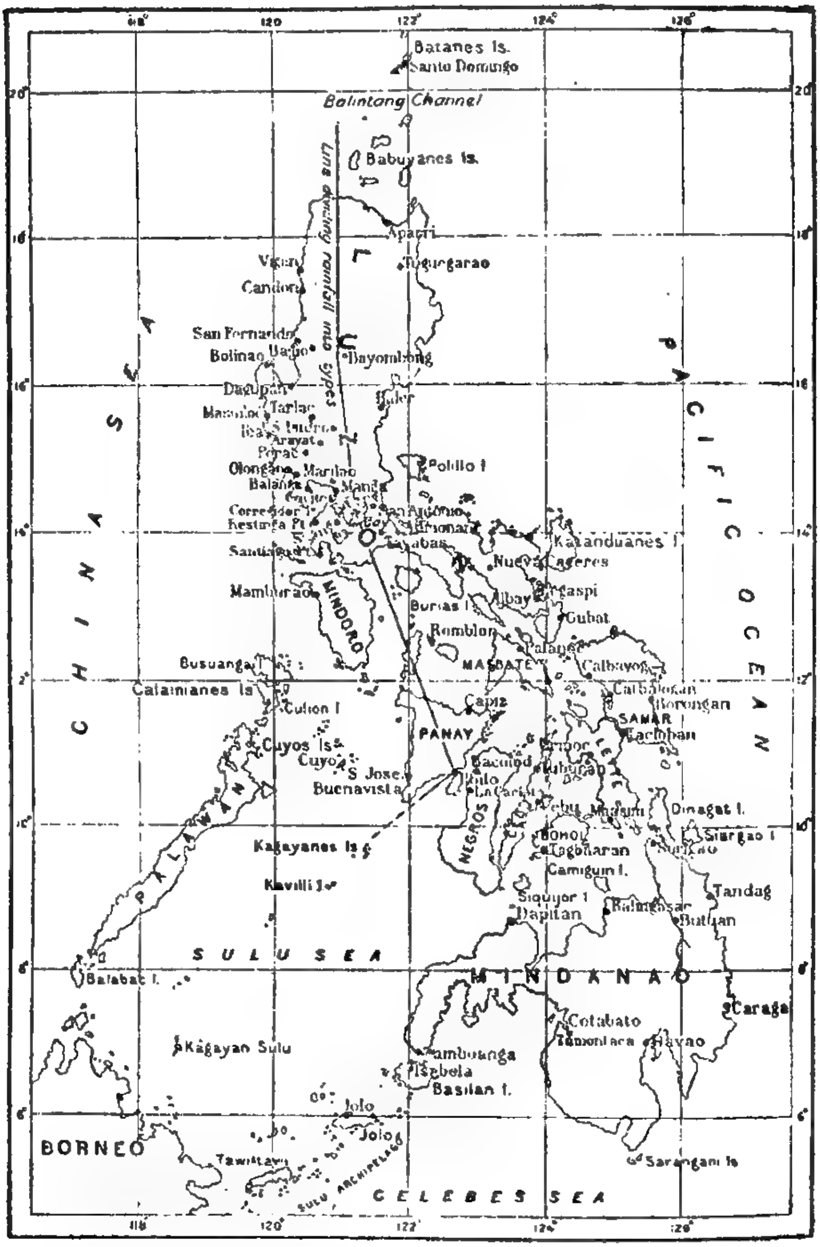

FIG. 1. Map showing two definite types of rainfall in the Philippines.

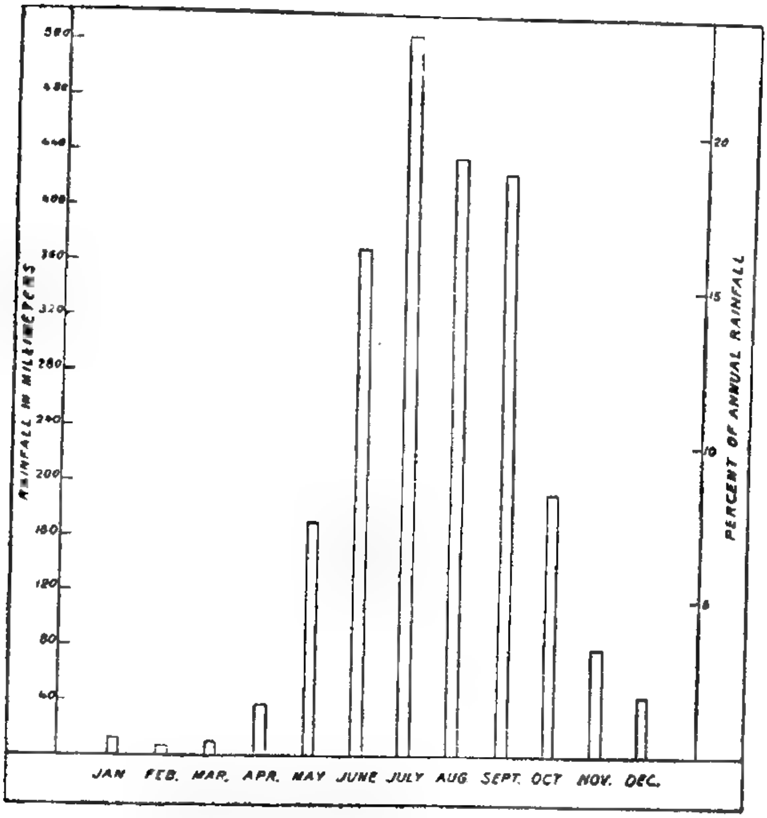

FIG. 2. Mean rainfall in the western portion of the Philippine Archipelago.

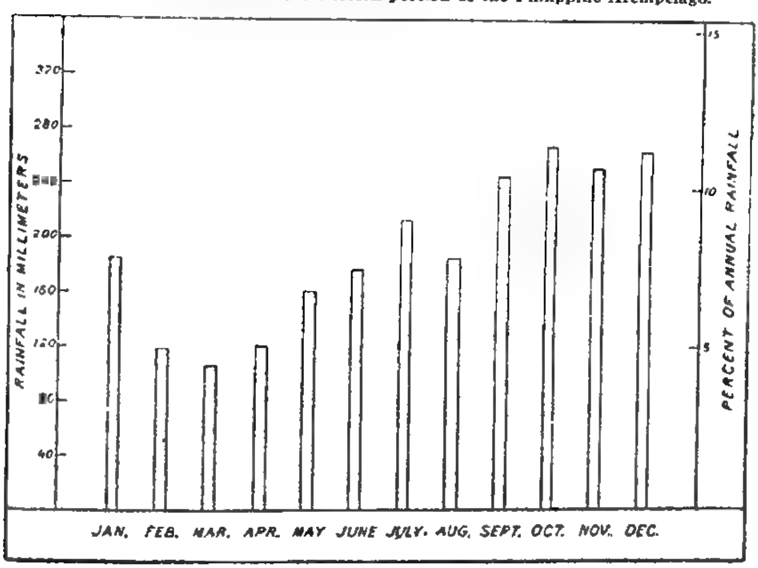

FIG. 3. Mean rainfall in the eastern portion of the Philippine Archipelago.

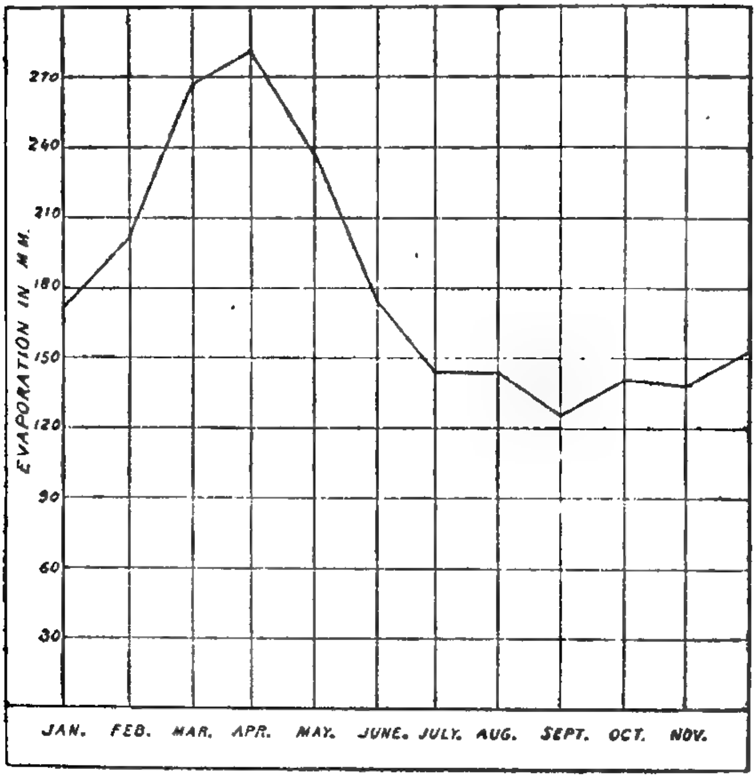

FIG. 4. Normal evaporation 1885–1907, Manila.

In view of the diminution in the rainfall and the high evaporation one would anticipate salt works using solar heat in the western half of the Archipelago to operate from December or January to April or May, which accords with the actual case.

DIFFERENT METHODS USED FOR THE MANUFACTURE OF SALT

A method commonly known in the Provinces of Batangas, Bulacan, Cavite, and Rizal by the name of *iras Tagalog* (native method) has been used in the Philippines as long as any of those now employed in the industry can remember and is probably the original method used in these Islands.

The process is as follows: Large areas of sandy land along the coast, approximately at the level of high tide, are cleared of vegetation and cleaned. The surface of the prepared land (*abuhan*) is loosened, and water from canals (*angkaw*), through which it is led in from the sea or from the estero, is sprinkled over the area where it rapidly evaporates. This process is repeated about four times a day for three consecutive days, until

a quantity of salt has accumulated on the surface. On the fourth or the fifth day the loose earth, together with the salt, is scraped into heaps and collected into leaching vats, called *hornohan* (from the Spanish "horno," which literally means "oven), where it is leached with sea water or weak brine until most of the salt has been extracted and a concentration of about 10 per cent of salt by weight is obtained. In many plants using the Filipino method the leaching vats are located at a point intermediate between the canals, where sea water is available. In this case the sea water is conveyed to the vats by means of an inclined bamboo pipe, the lower end of which rests upon an open-work bamboo basket, or other device, to prevent violent impact of the water, and the upper and larger end of which carries an earthenware jar (*pilon*) or galvanized-iron funnel to receive the water.

TABLE I.—*Mechanical analyses of soil used for evaporating salt water.*

[Numbers give percentages.]

Classification.	Sample from—		
	Las Piñas.	Bacoor.	Aplaya, Batangas.
Detritus, 2 to 1 mm	5.1	26.3	15.6
Fine earth, water-free basis:			
Coarse sand, 1 to 0.5 mm	1.8	11.1	7.0
Medium sand, 0.5 to 0.25 mm	5.2	17.4	22.9
Fine sand, 0.25 to 0.10 mm	9.5	12.6	30.4
Very fine sand, 0.10 to 0.05 mm	16.7	10.6	12.2
Silt, 0.05 to 0.01 mm	19.8	3.4	7.5
Fine silt, 0.01 to 0.002 mm	29.6	35.8	12.0
Clay (and salt) <0.002 mm	17.4	9.1	8.0

In the Philippines there are many salt-water shrubs and trees which when green have a specific gravity greater than that of water. In Rizal, Cavite, and Bulacan Provinces it is a common practice among Filipinos to pluck twigs of the plant known by the name of *culase* (*Lumnitzera racemosa* Willd.), which grows in the marshes near salt farms and along the levees of the evaporation reservoirs, strip them of their leaves, and throw them in the brine to test its strength. If they sink, the brine is not yet strong enough, but when they float, the brine is sufficiently concentrated to be transferred to the crystallizing ponds, called *banigan*. The specific gravity of the culase twigs of the size used has been determined by one of us to be about 1.085, or equivalent to 11.5 per cent by weight of salt. The culase varies from 1.070 to 1.096, depending on whether it is smaller

or larger than the size used by the Filipinos in determining the strength of the brine. There are very few Filipinos who use a specific gravity spindle or a salometer to determine the strength of the brine.

The leaching vat commonly used in Rizal and Cavite Provinces consists of a circular dike about 50 centimeters high and 4 meters in diameter, which is built on the ground. The bottom is covered with a layer of palm leaves, usually nipa, and rice husks, which filter the mud from the brine. By means of bamboo piping the filtered brine is drawn off through the dike into a shallow cement, earthenware (pilon), or clay-lined well. Dilute brine is dipped back into a leach, and the operation is repeated, until it becomes strong, when it is transferred to shallow crystallizing ponds.

After the leached mud has hardened slightly, it is marked off into squares. While the leaching is in progress, another layer of loose earth is being impregnated. This is scraped into heaps about the leach, while the squares of leached mud are drying. When the blocks have sufficiently hardened, they are thrown from the leach back on to the field. After the second crop of salty earth has been scraped into the leach, the clods are pulverized and carefully spread out again to be impregnated.

The crystallizing ponds are floored with smooth, broken pottery (tinajas or pilones) set in lime mortar to retard seepage and to prevent the admixture of sand with salt. The ponds are surrounded with bamboo fences covered with nipa or cogon grass in order to prevent the prevailing wind from blowing dust into them and the floating crystals from congregating on the leeward side. As the crystallizing ponds require more liquid, more and more of the strongest brine is added. It is poured through a straw-filled, open-work basket filter to remove rice husks, which may have gotten in from the leach, and especially to prevent disturbance of the bottom of the pond. When the brine is sufficiently concentrated to deposit salt, every day after sundown, when the temperature has fallen, to give the maximum crystallization, the crystals are raked into heaps at the side of the vats, gathered into baskets to drain, and finally conveyed into warehouses.

MODIFICATIONS OF IRAS TAGALOG METHOD

The iras Tagalog method is more or less modified in other parts of the Archipelago, but the principle of the process remains the same. In Antique, Cebu, Iloilo, Negros, and Palawan Provinces beds of bamboo split in half serve as crystallizing ponds.

In certain localities as, for example, Pangasinan Province low land below the tide level is used for evaporating salt water. In this case the depression is leveled, inclosed by dikes, and filled with tide water, which is evaporated by the sun's heat; when the water has disappeared, the surface crust is gathered up and leached as described previously. In this locality the leaching apparatus is frequently a small banca, in which a hole has been made at the bottom and covered with layers of straw and rice husk. The concentration of the brine is determined by throwing in it twigs of the guava tree. If they float, the brine contains the required amount of salt to be boiled, but if they sink, it is not yet sufficiently concentrated to be transferred to *cauas* (kettles). It is saved for leaching fresh amounts of salt-impregnated earth. The specific gravity of the first leachings, or concentrated brine, called *irna*, as determined by means of guava twigs, varies from 1.185 to 1.196.

People from Ambos Camarines, Albay, Bohol, Batanes, Capiz, Cagayan, Ilocos Norte, Ilocos Sur, Leyte, Misamis, Nueva Vizcaya, Pangasinan, Surigao, Sorsogon, Samar, Union, Zambales, and Mountain Provinces vary the process by evaporating to dryness the brine of the final leachings in cauas, or huge, thick, iron pans or kettles, mounted on rude clay furnaces. Sometimes the process is much less refined. A fire is built on the beach, and sea water is continually sprinkled on it, though not in such quantity as to put out the fire. Finally the fire is allowed to burn out, the ashes are leached, and the evaporation is made by artificial heat as above outlined. The crystals produced by boiling are formed rapidly and are, therefore, not so large, so hard, nor so desirable for packing purposes as those produced by slow evaporation.

In Japan a plan somewhat different from the method just described is employed.[15] The floor of the salt farm is made perfectly level and is covered with an even layer of clay, which is packed down and covered with a thick bed of coarse sand, which is kept loose by frequent raking. The sand is irrigated with sea water, led in through narrow ditches, which is allowed to evaporate. The process is repeated until the sand has become thoroughly impregnated with salt. The sand is then put in filters, sea water is poured on, and the brine which filters through is evaporated in pans over charcoal fires.

It is of interest to note the great similarity of the processes used in the Philippines for the manufacture of salt to the

[15] *Bull. La. Geol. Sur.* (1907), 7, 195.

processes used in China, where they either boil the brine or else evaporate it in the sun, according to a recent article,[16] from which we quote the following:

on the very first day of opening operations in the salt-works the seashore is cleared of weeds, and a beginning is made by digging out the upper layer of earth and breaking it up; this earth when broken up is turned over and over with bamboo poles until it is fine and smooth. Then sea-water is brought from ingenious receptacles, which are filled with water at high tide, and the earth is moistened with it, as with light rain, equally and thoroughly. Towards evening the earth is shovelled to one side, and a long line of mounds is formed of it, in order to protect it from rain during the night. On the following day the procedure is the same as on the previous day, except that the earth is carried to some particular spot for safety. In fine weather it is taken out again from time to time, and dried on the salt-grounds.

As soon as the earth has been thoroughly prepared, i. e., is completely impregnated with salt particles, the workers take it to the ovens. These ovens [not a real oven but a leaching vat], which are shaped like chests, 9 ft. long, 2 ft. broad, and 3 ft. deep, are called Lu; near each a well 8 ft. deep is dug. The floor of the oven is strewn with rotten wood; above this are fine bamboos; on them is a layer of brushwood, and above all is a layer of ashes of plants. The prepared earth is shot upon this, beaten hard and covered with rice straw. On this is poured sea-water, which finds its way through all the inner layers, and flows into the well as brine. Each oven in 24 hours gives more than 20 *tan* (60 pud) of pure brine, which is drawn out of the well and taken to the boiling oven to be boiled * * *. Each boiling begins at 11 p. m. and continues until 10 o'clock on the following morning * * *. It appears in three qualities and colours: white, dark and yellow: the white is the best, the dark not so good, and the yellow much inferior and of a bitter taste.

The second method * * * is distinct from the first, in that the brine is not boiled, but poured into peculiar paved tanks, and left there to the sun and wind. For complete evaporation two days in summer, and 3–4 at other times are sufficient, and indeed the N. W. wind is quite as favorable to this operation as are the sun's rays; on the other hand, with unfavorable winds, and in rainy weather, no salt is taken.

Another method in use in the Philippines, introduced in recent years by the Chinese, utilizes most of the lower areas—that is, the vast stretches of overflowed tide lands, or salt marshes, at the head of the bays or along the coast line. The land best suited is that flush with an ordinary tide, so that it may be covered from 30 to 50 centimeters deep by a high tide. The land, having been cleared of vegetation and débris, is first leveled and then diked with levees a meter or more high. It is then partitioned off into reservoirs, shallow evaporation lakes, or stock ponds of different sizes, depending on the size of the plant itself, for receiving, settling, and evaporating the sea

[16] *Far East. Rev.* (1912), 9, 303.

water and precipitating the silica, oxide of iron, calcium carbonate, and calcium sulphate.

The reservoir in which the first evaporation takes place is usually a fish pond; in addition to this, there are in most salt plants three rows of shallow concentration reservoirs, seldom less than four in a series, and often six or seven. The brine is drawn from one reservoir to another as it strengthens and decreases in volume by evaporation, and new water is in turn admitted from the bay. Beyond the reservoirs crystallizing ponds are constructed in the manner already described. Seepage from the crystallizing ponds is collected in ditches, which carry it to a well, from which it is baled out with a bamboo sweep into another ditch, which returns it to the evaporation reservoirs containing the strongest brine. When the crystallizing ponds are higher than the evaporation reservoirs the brine is dipped up by hand; sometimes it is poured into an apparatus similar to that used in filling the leaching vats, allowed to run through a straw filter, and thus transferred to the crystallizing ponds. When land above tide level is employed for the greater part of the manufacturing plant, the water is elevated with a bamboo sweep. In the ideal plant the whole process is by gravity.

Water transportation connects most or all of the salt works with deep water, from where connection can be made via navigable streams with many of the inlands provinces.

The working season for the plants along Manila Bay varies somewhat from year to year, but usually begins in December and continues until about May—a period of approximately one hundred fifty days.

The product obtained by the process above described is coarse and not usually of the best quality, as it contains magnesium salts and other impurities. The brine thus treated will not give a product containing much over 93 to 94 per cent sodium chloride. If, however, the mother liquor containing the bulk of impurities—that is, most of the magnesium and sodium sulphates and practically all the magnesium and calcium chlorides—is removed from time to time, a much higher grade of salt may be produced.

The magnesia and lime content of Philippine salt are shown in Table II.

The first concentration or evaporation reservoirs are preceded by a fish pond, not shown in figure 5, specific gravity 1.025, which is supplied at its intake with water having a specific gravity of 1.024. In all of the Philippine plants the brine was transferred from the evaporation reservoirs to the crystallizing

TABLE II.—*Showing the magnesia and lime content of Philippine salt.*

[Numbers give percentages.]

Source.	Calcium oxide (CaO).	Magnesium oxide (MgO).	Remarks.
Parañaque (1) (1911)	0.96	0.86	Prepared from estero water. Filipino method.
Parañaque (2) (1911)	1.24	0.84	Prepared from estero water. Chinese method.
Malabon (1911)	1.66	1.93	Do.
Obando (1911)	0.79	1.81	Do.
Obando (1) (1913)	0.33	0.33	Do.
Obando (3) (1913)	0.70	0.45	Do.
Obando (4) (1913)	0.78	0.39	Do.
Obando (5) (1912)	0.34	0.73	Do.
Obando (6) (1912)	0.47	0.67	Do.
Ahinan	6.14	trace	Salt spring.
Ahin	4.03	1.43	Do.
Bayombong (5)	trace	0.25	Do.
Bayombong (6)	0.55	trace	Do.
Bayombong (7)	1.74	0.50	Do.

pond at a density never greatly exceeding 1.13, the concentration at which gypsum begins to deposit, which is too soon. Fig. 5 gives the concentrations of the brine of a plant in actual operation. The effect is readily noticeable on the composition of the product, which contains a high percentage of lime. The bitter salts are not removed from many of the crystallizing ponds, and the effect is evident in the high magnesia content of the salt. The lower magnesia content of the Parañaque sample given in Table II is due to its being an early crop before the bitterns had become greatly concentrated.

The salt produced by the old Filipino method has acquired a reputation for its superior qualities for curing fish. Many a Filipino will say that it takes more of the salt produced by the new, or Chinese method, to preserve a given weight of fish.

In the old process the water is evaporated to dryness, and gypsum, which is not readily soluble, is largely eliminated, for only a small amount of it is redissolved in the leaches. In this way the separation is more complete than is now common practice in the new method, where the brine is transferred to crystallizing ponds too soon. By the old method, particularly, the salt was usually retained in warehouses for some time. With the new method salt is produced in large quantity and is frequently sold directly after draining and before the pile has weathered and the hygroscopic salts have been washed out by the absorption of moisture from the air. These differences

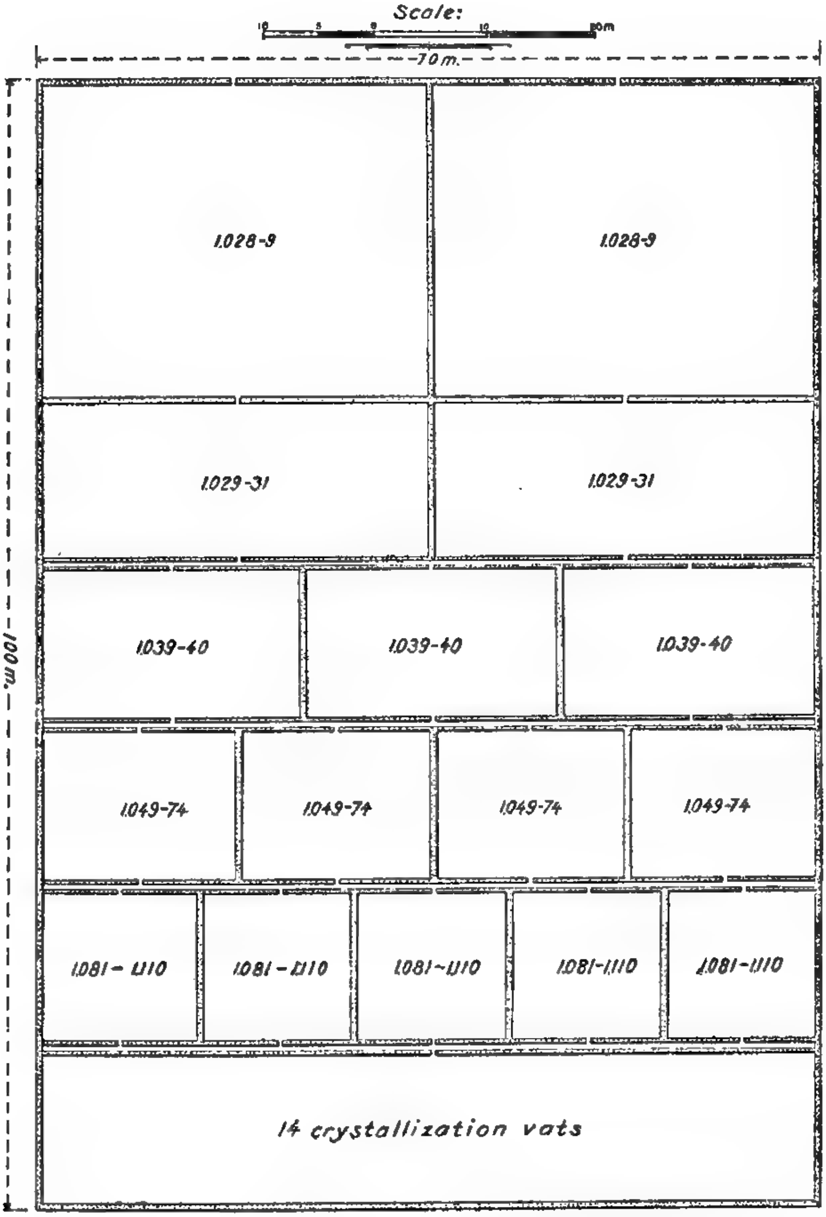

FIG. 5. A general diagram showing specific gravity of brine in the different concentration reservoirs of plants in actual operation.

are the only ones which exist. With proper manipulation the salt produced by the Chinese method will have as high a percentage of purity and a whiter color than that produced by the Filipino method.

So far as we have been able to determine, the area devoted to crystallizing ponds in plants using the process introduced by the Chinese is one sixth to one fifth (excluding the fish pond), or even more, of the area covered by the evaporation reservoir. However, taking into consideration the fact that for the more complete separation of the less soluble salts the volume of the brine should be reduced more than is done in common practice, the above ratio is much larger than is necessary.

In order to carry on the process of evaporation in the most efficient way, the following facts should be given due consideration:

1. The rate of evaporation for any solution decreases as the concentration is increased. Accordingly, in order to counteract retarded evaporation in the various steps of the process a slightly greater than proportional surface area is needed in succeeding concentration reservoirs. This fact is almost negligible except in fairly concentrated solutions and is probably more than compensated by seepage. The latter varies, depending on the nature of the soil, and the average should be determined and taken into consideration in the construction of a plant.

2. The capacity and surface area of the evaporation reservoirs of any row should be proportional to the quantity of brine delivered from the reservoirs of the preceding row.

3. The specific gravity of the brine should be controlled in such a way that each row of evaporation reservoirs should receive and deliver a brine of definite specific gravity.

4. The area occupied by the crystallization vats should be as small as possible to accommodate the brine concentrated in the evaporation reservoirs, for in that way as much salt can be obtained with less labor.

If we neglect the effect of the precipitation of the less soluble salts (calcium sulphate, calcium and magnesium carbonates, oxides of iron and alumina, etc.) on the density of the brine during the process of concentration, we can establish for practical purposes the principle that the density of the brine varies inversely proportional to its volume and for a given depth inversely proportional to the superficial area.[17]

The salt supply of Mountain Province for the greater part comes from Cervantes and is sold to the people at exorbibant prices. The people of Mountain Province also produce a very

[17] On this basis the approximate volume of the brine at any given density may be determined and the corresponding size of the concentration reservoir to contain it may be calculated.

small amount of a poor grade of salt by evaporating water from the carbonated brackish springs at Mayinit, Bontoc; Tukukan, Ahin, and Bungubungna, Ifugao; and Salinas, Nueva Vizcaya.

TABLE III.—*Chemical analysis of some waters used for the preparation of salt.*

[Numbers give parts per thousand.]

Source.	Iron and aluminium oxide (R_2O_3).	Calcium oxide (CaO).	Magnesium oxide (MgO).	Potasium oxide (K_2O).	Potassium calculated as potassium chloride (KCl).	Sodium oxide (Na_2O).
Ahinan Spring, west flow of Guadalupe crater	trace	4.022	0.049	0.085	0.135	5.488
Tukukan Spring	0.008	0.333	0.066	0.919	1.454	2.334
Ahin Spring	0.027	0.618	0.255	1.242	1.965	5.021
Mayinit hot spring	0.088	0.128	0.001	0.023	0.036	0.457
Balatok Spring	0.085	0.868	0.007	1.580	2.500	8.688
Malabon estero	0.036	0.854	2.078	0.717	1.134	14.15
Parañaque estero	0.028	0.654	1.025	0.764	1.209	13.18

Source.	Sodium calculated as sodium chloride (NaCl).	Silica (SiO_2).	Chlorine (Cl).	Sulphuric acid radical (SO_4).	Carbonic acid radical (CO_3).	Bromine (Br).
Ahinan Spring, west flow of Guadalupe crater	10.340	0.023	11.09	8.463	----------	----------
Tukukan Spring	4.397	0.103	3.33	0.035	----------	----------
Ahin Spring	9.461	0.106	6.89	0.151	----------	----------
Mayinit hot spring	0.861	0.195	0.75	0.295	0.208	----------
Balatoc Spring	16.370	0.317	11.59	0.236	----------	----------
Malabon estero	26.660	0.024	20.96	2.626	----------	0.185
Parañaque estero	24.830	0.008	18.84	2.780	----------	0.243

It is not known just when the salt springs were discovered. The supply of brine varies in quantity and in strength. In some places it is not large and of little or no present economic value, but it could probably be developed. The result of the abnormal price is that in certain places at certain times of the year the entire supply of brine is used by operators who take turns at the spring.

Most of the plants now used are very much like those described in ancient history. They consist of a few cauas, obtained from the Ilocanos, mounted on crude furnaces built of stone and clay. There are no furnaces with a large number of kettles, and often there is only one kettle to a furnace. At present there is little attention paid to the economy of heat, although eventually the

success or failure of the process will depend on whether or not there is economical application and thorough utilization. The salt obtained in this way is very inferior, as no method is adopted to separate the salt from the mother liquor or other impurities, either organic or inorganic. In this crude way about 12 kilograms per day per kettle are manufactured. By the old solar method the average daily production per laborer varies from 14 to 85 kilograms of salt, depending on the locality and the refinement of the process, while the average production for the new process is about 200 kilograms of salt per laborer per day.

At Mayinit the salt water is hot, contains 0.3 per cent by weight of salt, and flows from the spring in several shallow streams. Salt houses are built over carefully leveled plots of clayey soil, upon which water from the stream is led. There are more than 100 such houses, usually about 4 meters wide and from 4 to 8 meters long, with grass-covered roofs extending to the earth. The ground space of the salt house is paved with stones from 10 to 15 centimeters in diameter. The hot water is allowed to spread out and pass among the bases of these stones; thence it is carried up on the stones by capillarity and evaporates fairly rapidly from the exposed hot surfaces, leaving a thin crust of salt.

About once each month the salt is gathered by washing the encrustation from the stones into a large wooden trough, called a *ko-long-ko*. Each stone is thoroughly washed and then replaced in the pavement. The saturated brine is preserved until sufficient is gathered for evaporation, when it is boiled as above described. The product is pressed into cakes and placed upon bits of broken earthenware and is baked either in the fire or in the sun. The dried salt contains only about 87 per cent sodium chloride.[18]

The flow of the springs at Tukukan and at Ahin is probably about 500 liters per hour each and contains 0.6 and 1.2 per cent of salt, respectively. The Tukukan spring is rather inaccessible, but that at Ahin is on the bank of the river down which is floated the necessary wood for the furnaces, from the pine forests above. The Ahin spring comes from a crevice in the solid rock and could probably be developed.

In July, 1910, there were a dozen kettles in operation, which consumed the entire output of the spring at Bungubungna.

At Salinas the sight of the two springs is wonderful aside from the salt-making operations. The brine comes from the springs

[18] Jenks, A. E., *Pub. P. I. Eth. Sur.* (1905), **1**, 145–7.

in the side of the mountain highly charged with carbon dioxide, under which condition it carries, besides 3.2 per cent of salt, large quantities of lime and some iron in solution. On reaching the surface, where the pressure is released, the carbonate of calcium is deposited, and in this way the springs have built up huge mounts of mineral deposits.

A portion of the water is collected and carried nearly 2 kilometers through troughs made of split bamboo. These are very rapidly coated with sulphate and carbonate of calcium in that portion of the line nearest the spring, the amount of coating decreasing fairly rapidly with distance. In fact, the objects of carrying the water so far through open troughs are to get rid of the undesirable substances which precipitate before the salt and also in order that firewood may be closer at hand for the boiling.

Hardwood logs are used for fuel and are shoved in from both sides of the furnace, so that the points meet at the center. As the points burn off, the logs are shoved in farther. Practically the only cost of producing salt here is the cost of getting out the wood. About 70 pans were in operation in June, 1911.

Only a small part of the water which is at present flowing from these springs is utilized, yet it furnishes 125,000 kilograms of salt annually for a population of about 50,000 people. Thus there ought to be an opportunity for doing away with kettles and open pans and starting a modern concentration plant with steam heat.

There is some coal in Nueva Ecija, and coal is as good as fuel and is even better for salt vacuum pan or grainer units than wood. In general, when kettles and open pans are used, they are placed over a long combustion chamber in direct contact with the flames from the furnace. Steam heat is more frequently used when vacuum pans are employed. The grainer process requires steam heat exclusively. The steam is carried through pipes submerged in the brine. The temperature is varied by varying the pressure, so as to obtain salt having the desired grain. This process is now much more generally used in the United States than any other. The removal of the gypsum depends upon a quiet, regular boil of the liquid, which cannot be uniformly obtained in all the kettles of a block, and therefore the quality of the salt is variable. Furthermore the heat causes the calcium sulphate to form a scale, which clings to the kettle and thus reduces the efficiency. The general result is that a better quality of salt is produced, and about 50 per cent more evaporation is

effected by a given quantity of fuel when it is fired under a properly constructed boiler to produce steam for heating purposes than in any other way.

The history of the development of brine in the United States is that the brine is stronger and more plentiful with depth. At East Saginaw, Michigan, brine of 1° was struck at 90 feet (27 meters) and increased until at 636 feet (193 meters) 90° brine was reached.[19] It may be possible that the rock from which the brine springs emanate lies deep, and a mass of rock and earthy matter will have to be penetrated before the source can be reached. Again the brine of the Mountain Province springs is probably diluted by surface seepage and a stronger brine may perhaps be obtained by developing the springs and bringing the brine to the surface undiluted. On the other hand, the salt may have its origin in sands, silts, clays, or shales saturated with salt from sea water during deposition and in which the impregnated salt has been preserved by the overlying strata.

Formerly the Philippines produced practically enough salt for domestic consumption. This is no longer true. The imports of salt into the Philippines have exhibited an almost constant increase since American occupation. The exports of domestic salt have had no influence on the trade, amounting to nothing except in 1907, when there were 4,280 dollars worth exported, of which 3,196 dollars came from the port of Zamboanga and 330 dollars from Manila, presumably the product of Malabon. Salt pays an import of 20 cents per 100 kilograms when crude and 50 cents per 100 kilograms when ground, powdered, or otherwise manufactured, and the fact that in the only year in which the local supply has equaled the demand Zamboanga was able to supply its local needs and to furnish a surplus for exportation seems to argue that the rates imposed are sufficient for the protection of the local industry. In recent years there have been no exportations. It is interesting to note the sources and value of our imported salt.

The principal source of our importations is China, which sends only coarse salt brought in shipments of from 1- to 300-bag lots. This indicates that the local production of salt does not keep pace with the growth of the packing industry. Prior to 1907 there was not so great a demand for salt for packing purposes. By actual count in 1907 there were but five Chinese engaged in the packing of sardines in Tondo, but before the great Tondo

[19] *18th Annual Rept. U. S. Geol. Surv.* (1897), 5, 1304.

TABLE IV.—*Showing source of imported salt.*[a]

[Value in dollars, United States currency.]

Source.	1901	1902	1903	1904	1906	1907
United States						
United Kingdom						
Belgium						
Denmark						
France						
Germany						
Spain						
China						
Singapore						
All other British East Indies						
Japan						
British Australasia						
Total	3,693	8,583	20,985	5,176	1,852	2,321

Source.	1908	1909	1910	1911	1912	1913
United States	216	137	114	2,030	6,026	5,069
United Kingdom	2,322	2,504	4,508	3,061	4,938	3,244
Belgium			4			
Denmark				68		
France		5		41		
Germany	24	29	51	56		
Spain		11	9	6		
China	396	67,557	51,498	54,102	49,187	47
Singapore	38	206	171	1,204	182	216
All other British East Indies		405	95			
Japan				171	816	1
British Australasia	39	238	299	366	142	324
Total	3,085	71,092	56,775	61,105	61,291	8,901

[a] No figures obtainable for 1905. The Philippine Customs reports are issued in dollars U. S. currency.

fire of 1911 there were thirty-six in that section of the city, each using large amounts of coarse salt for the purpose of curing fish.

Considering the increased importation and the import tax of 25 per cent ad valorem, the manufacturers should find a great deal of encouragement and there should be a good margin. If the producer here had to compete with the salt of the United States at an average price of 44 centavos per kilogram, which includes not only the cheap grades of salt, such as the coarse salt made here by solar evaporation, but also the very finest grades of table and dairy salt, which are prepared with great care and expense and which constitute a considerable percentage of the total, it would be more difficult. However, the manufacturer in the Philippines has to compete only with salt produced by the same methods as he himself employs and is protected by the

tariff regulation. As yet the only product in the Philippines has been coarse salt, for there has been sufficient demand from tiendas and packers to consume it entirely as such.

SALT MILLING

So far as we have been able to determine, there have been no attempts at salt milling in the Islands. A short description of this process may not be out of place.

Each mill is constructed with one or more sections containing a drier, several sets of rolls, fans, shaking sieves, etc. The modern plants use rotary driers consisting of two concentric cylinders clamped together and rotating on bearings which support the outer cylinder. The inner cylinder, or steam drum, is about 1 meter in diameter and is fed with live steam. The outer cylinder is about 2 meters in diameter and 15 meters long, through which hot air is blown. The dryer is set at an inclination of about 3 or 4 degrees. The salt is fed into the space between the two cylinders at the upper end, and as the drier revolves the salt slowly travels toward its lower end where it is discharged. It is then carried to the first set of rolls. After passing through these, the crushed material is sent over a shaking sieve, which acts as a separator, allowing the fine stuff to go to the bagging room, while the coarser material is conveyed to a second set of rolls, which are set closer than the first and, therefore, give a finer product. This is again sieved, separated, and crushed in still finer rolls, the process continuing until the material has passed through several sets of rolls of increasing closeness, passing over sieves after each crushing. Salt of various coarseness is produced by the use of sieves of varying mesh which feed into different bins. Fans are placed over the top of each sieve and also in the rolls and driers. These fans take off the very lightest and finest material, and their product is conveyed into a room where it is pressed for cattle feed. As the magnesium and sodium sulphates are considerably lighter than the sodium chloride, the use of these fans takes out much of the sulphates and purifies the salt very appreciably, as demonstrated by analysis.

Few statistics of the salt produced in the Philippines have been kept, and it has been necessary for us to gather ours partly by letter. Some manufacturers returned replies very complete, others very lacking in essential features, though we believe all are fairly satisfactory with regard to output. We have carefully studied the plants in Obando, Malabon, Las Piñas, Parañaque, Bacoor, Kawit, and the principal producing towns of Pangasinan. In many places a suspicion that we were gathering data as a basis for taxation kept the men engaged in the industry from giving information freely. Since there is no basis of comparison, it is impossible to prove a large increase in the local production. Information from municipal presidentes shows that there were 105 municipalities representing 30 provinces where salt is manufactured and that in round numbers 19,000,000

kilograms were produced in 1911, all of which was coarse salt.[29] In reporting the production some operators used the cavan as a unit of measurement, others the *simat*, and others the *curibot* or *babaco*. For the sake of convenience the product has been reduced to kilograms on the basis of 1 cavan equals 49.5 kilograms. Some of the data obtained from municipal presidentes give the results expressed in Tables V and VI.

TABLE V.—*Annual production of salt in the Philippine Islands by solar evaporation.*

Province.	Process used.	Production.
		Kilos.
Antique	Filipino	110,254
Bataan	do	112,560
Batangas	do	1,299,870
Bohol	do	27,353
Bulacan	Filipino and Chinese	71,280
Cavite	do	2,006,312
Cebu	Filipino	482,660
Iloilo	do	943,357
Mindoro	do	49,500
Moro Province	Chinese	991,200
Occidental Negros	Filipino	95,056
Oriental Negros	do	33,896
Palawan	do	34,650
Rizal	Filipino and Chinese	7,055,400

TABLE VI.—*Annual production of salt in the Philippine Islands by artificial heat evaporation.*

	Kilos.
Albay	small amount
Ambos Camarines	27,000
Batangas	([a])
Bohol	([a])
Cagayan	40,830
Capiz	491,280
Ilocos Norte	783,051
Ilocos Sur	1,983,233
Leyte	2,640
Misamis	40,800
Mountain Province	11,400
Nueva Vizcaya	125,000
Pangasinan	1,026,835
Samar	2,817
Sorsogon	9,900
Surigao	4,000
Union	445,585
Zambales	356,181

[a] See Table V.

[29] The total production of salt in the United States in 1909 was 3,825,000,000 kilograms, worth 16,688,000 pesos. The production in the Philippine Islands looks somewhat small; however, it is not so small from the standpoint of the other industries.

The importance of salt production as a Philippine industry, where its rank, with reference to a number of items, is given, is well shown in Table VII.[21]

TABLE VII.—*Comparative table of industries.*

[Numbers indicate rank in comparison with all other Philippine industries.]

	Salt.	Black-smithing.
Number of establishment	[a] 11	[b] 13
Capital invested	[c] 15	33
Number of employees	[d] 10	25
Average monthly wages	9	22
Cost of materials purchased	52	29
Value of product	[e] 30	[f] 26

[a] Forty-nine establishments distributed as follows: Cavite, 14; Cebu, 5; Iloilo, 4; Rizal, 16; Zamboanga, 6; Batangas, 1; Bohol, 1; Nueva Vizcaya, 1; Sorsogon, 1.
[b] Forty-three establishments in 7 provinces.
[c] Capital, 245,952 pesos.
[d] Total number of wage earners, 841.
[e] Value, 91,284 pesos.
[f] Value, 119,470 pesos.

The various elements which make up the cost of an article of commerce are found exemplified in the simplest and clearest manner in the salt industry of the Philippines. The raw material, sea water, has no value other than that given it for the most part by unskilled labor expended in reducing it to salt and the cost of the tideland involved. In the comparative table of industries taken from the Census of the Philippine Islands, above referred to,[22] the cost of materials purchased is less than that for any other industry. The introduction of the use of reservoirs for evaporating the sea water is in the nature of a labor-saving machine, and here we have to consider the interest on the investment as part of the cost.

In the Philippines no effort is made to derive profit from the by-products. In certain localities in the United States the entire profit of the salt industry has been from by-products. In fact, in some plants the salt alone is made at a financial loss, but the bromide and calcium chloride have yielded sufficient returns to keep the furnaces active.

During the period from December 1, 1910, to May 31, 1911, more than half of the water evaporated from the ponds was returned to them by rain, so that operations on the salt farms were much interfered with and at times suspended. Out of the season

[21] Census of the Philippine Islands (1903), 4, 476–7, 486, 496, and 524.
[22] Loc. cit.

of six months it rained on thirty-two days; on eighteen of these days more water fell into the ponds than was evaporated from them. Even in the most favorable four months of this season more than one fifth of the water evaporated from the ponds was returned by rain and therefore the effective evaporation was only four fifths of the apparent. If the ponds had been covered during the whole period, four fifths as much water would have been evaporated as was evaporated in free exposure; in other words, if the ponds had been covered during the whole season, the evaporation would have been at the rate of the effective evaporation during the most favorable month, but with the proper system it would have been unnecessary to cover them except on the days when there was precipitation.

Solar salt is manufactured at Syracuse, New York, and other places by evaporating brine on so-called covers—shallow wooden vats provided with light, movable roofs arranged in such a way that they can be easily shoved over the vats when it rains. The improved process consists in the use of "aprons," or very wide, shallow troughs, in complete exposure to the sun, air, and wind, which convey the brine from the wells to the salt fields; these are 5 to 6 meters wide by 6 or 7 centimeters deep. Upon this the brine, kept at a depth of from 1 to 2 centimeters, flows slowly, depositing the gypsum and being delivered in a saturated condition to the covers. The grade is usually from 1 centimeter to 10 meters. Under the aprons are deep rooms or tanks so placed that, in case of rain, the brine on the apron can be discharged into the deep room, where it is protected from dilution, remaining there until the return of fair weather, when it is pumped back into the apron, from which all rain water has been drained. With this improvement the efficiency of a cover has been increased over 80 per cent in many instances.[23] Natural brines, which are sometimes very dilute, are often concentrated by dripping over extensive ricks composed of twigs. In the Philippines, where nipa and grass roofs are so cheap and comparatively durable, we believe a great deal might be done in the adaptation and utilization of these ideas.

The following illustration will serve to show the saving to be effected by the use of covered vats. A crystallizing pond one meter square originally costs about 1 peso; the annual upkeep is

[23] *Annual Rept. Supt. Onondaga Salt Springs, N. Y.* (1851), 27; ibid. (1869); Goessmann, C. A., Rept. on the manufacture of solar salt, Syracuse (1864); Carrignes, S. S., Statistics relating to the silica interests of Michigan, Lansing (1881), 23; Chatard, T. M., *7th Annual Rept. U. S. Geol. Surv.* (1886), 506.

about 5 centavos, and the annual yield is about 100 kilograms of salt. By the use of covers the average annual yield could be increased to 118.7 kilograms and in exceptional seasons to 153 kilograms with very little additional labor. The original cost of arranging movable roofs in such a way that they can be slid easily over the vats when it rains would not exceed 50 centavos per square meter, and the life of the roofs would be at least five years. The increased output of an average season would return 50 per cent of the additional outlay, and in exceptionally favorable seasons this would be increased three-fold. Furthermore the season could be considerably prolonged, thereby still further increasing the yield. No strong brine would ever be lost at the end of the season, as the evaporation could be finished entirely under cover, if necessary.

The fact must be recognized that the producers, in general, are not obtaining the best practical results. Many of them are unwilling to change their methods, while others cannot without previous study, for which they have neither time nor opportunity. The foundation for such a study is the collection of manufacturing statistics from the native works and their careful comparison with each other and with the best results of foreign practice. The results of our study thus far lead to the following conclusions.

CONCLUSIONS

The brine should not be transferred to the crystallizing ponds until the salt is ready to crystallize out (specific gravity, 1.205; 25°C.), for in the evaporation reservoirs large quantities of gypsum and other matter had precipitated before the salt settled out. If there is a proper balance in the plant, in at least the last two reservoirs large quantities of undesirable substances will be removed and a purer grade of salt will result.

The area occupied by the crystallizing ponds should be as small as possible to accommodate the brine concentrated in the evaporation reservoirs, for in that way as much salt is obtained with less labor. When the strength of the brine in the crystallizing ponds has attained 1.275 specific gravity (29°C.), it should be drawn off and worked over for the by-products or should be discarded. Experiments show that salt with a purity of 99.63 per cent sodium chloride may be obtained with these precautions.[24] Effort should be made to improve the quality of the output and to develop a larger industry in the Philippines.

[24] *18th Annual Rept. U. S. Geol. Surv.* (1897), 5, 1311.

ILLUSTRATIONS

PLATE I. Diagram indicating deposition of salt from sea water, showing the impurities precipitated before, with, and after the salt.

PLATE II

FIG. 1. Instrument used in sprinkling water over an area from the canals.
2. Another type of instrument used in sprinkling water over an area. This process is repeated until a quantity of salt has accumulated on the surface whereupon the loose earth, together with the salt, is scraped into heaps.

PLATE III

FIG. 1. A view of heaps of the salt-impregnated earth ready to be transferred to the leaching vats. In the background are to be seen crystallizing ponds protected from the wind by a bamboo fence.
2. A leaching vat built on the ground, but high enough so that the mud may be removed by gravity after the leaching is completed.

PLATE IV

FIG. 1. A view of another leaching vat, showing the cement-lined receptacle into which the brine drains; also the implements for scraping the loose earth into heaps, in transferring the salt water from the canals to the leaching vats; a basket filter to break the force of the sea water or brine so it will not displace the loose earth; also how the mud flows are stopped during the leaching process.
2. A leaching vat from which the leached mud has been removed preparatory to refilling.

PLATE V

FIG. 1. An apparatus used for transferring salt water from a canal to a leaching vat. It is simply an earthenware receptacle (pilon) into which the water is poured and from which it is carried to the leaching vat by means of a bamboo trough.
2. A view of the leaching process.

PLATE VI

FIG. 1. Marking off the leached mud into squares after it has hardened slightly.
2. A more developed and more progressive type of leach. A kind of cultivator used in loosening the soil is also shown.

PLATE VII

FIG. 1. Throwing the hardened blocks from the leach back on to the field. After the second crop of salt-impregnated earth has been scraped into the leach, the clods are pulverized and carefully spread out to be again impregnated.
2. Refilling a leach.

PLATE VIII

FIG. 1. A view of the Filipino process, showing the loosened soil and the instruments with which the loosening is done, the canal from which the sea water is obtained, leaches in various stages of rotation, and crystallizing ponds protected from the wind.

2. A filter through which the brine is poured when it is transferred to the crystallizing vats.

PLATE IX

FIG. 1. A row of caua sheds on a dike in Binmaley, Pangasinan. In the background is an arm of the sea from which salt water is led into the depression in the foreground, where it has been evaporated and from which the impregnated earth is scraped up and leached out.

2. A crude furnace for evaporating the strong brine obtained from an improvised banca leaching vat.

3. Basket measures filled with salt for the retail trade.

PLATE X

FIG. 1. The evaporation reservoirs of a salt farm, where the salt is produced by the Chinese method.

2. The crystallizing ponds of a salt farm, where salt is produced by the Chinese method. These are built on sandy soil, and as the brine seeps through, ditches carry it to a well from which it is returned to the evaporation reservoir containing the strongest brine.

PLATE XI

FIG. 1. The salt pile and the warehouse are being built simultaneously.

2. A salt warehouse, and a day's crop from a farm, in Malabon, Rizal, where salt is produced by the Chinese method. The salt is allowed to drain in baskets for twenty-four hours before it is dumped into the warehouse.

PLATE XII

FIG. 1. The crystallizing ponds of a farm at Obando, Bulacan, using the Chinese method for making salt.

2. An apparatus used for transferring brine from evaporating reservoirs to crystallizing ponds which are on a higher level.

PLATE XIII. Salt houses at Mayinit, Bontoc.

PLATE XIV

FIG. 1. Stones incrusted with salt, Mayinit, Bontoc.

2. Washing the crust of salt from the stones, Mayinit, Bontoc.

PLATE XV

FIG. 1. Gourd used in Bontoc for storing salt meats.

2. Packages prepared for transportation. Reduction × 5.

PLATE XVI. An interior view of the salt furnace at Ahin, Ifugao subprovince, Mountain Province. The type of salt package is shown by comparison with the canteen. (Photograph taken and loaned by courtesy of Mr. H. Otley Beyer.)

PLATE XVII

FIG. 1. A near view of the Salinas salt springs, ~~Mountain Province~~. N. Vy.
2. The lower end of the bamboo trough from the Salinas salt springs, showing the well from which the brine is carried to the evaporating pans.

TEXT FIGURES

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3. Mean rainfall in the eastern portion of the Philippine Archipelago.
4. Normal evaporation 1885–1907, Manila.
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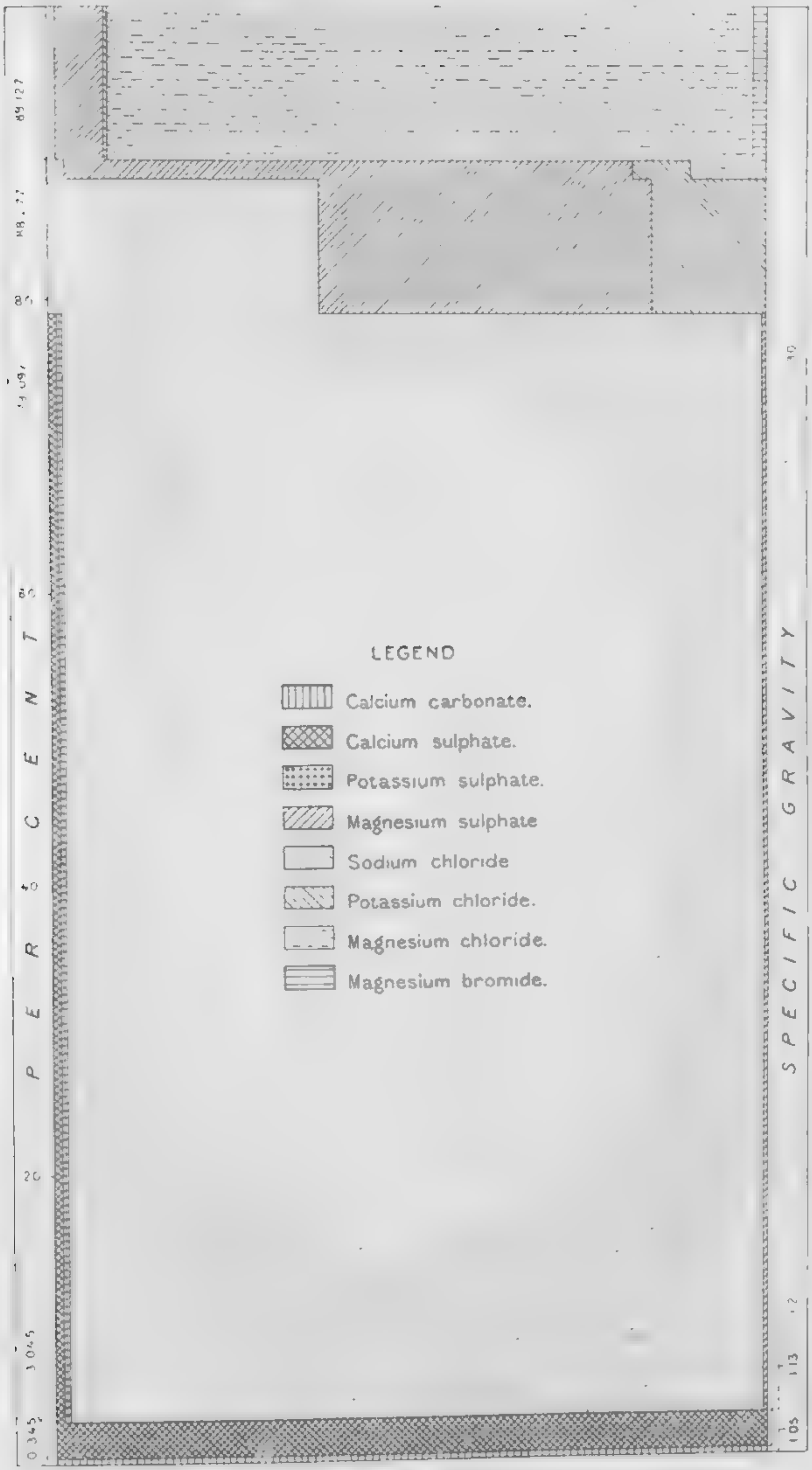

PLATE I. DIAGRAM INDICATING DEPOSITION OF SALT FROM SEA WATER.

Fig. 1.

Fig. 2.

PLATE II. INSTRUMENTS USED IN SPRINKLING WATER OVER AN AREA FROM THE CANALS.

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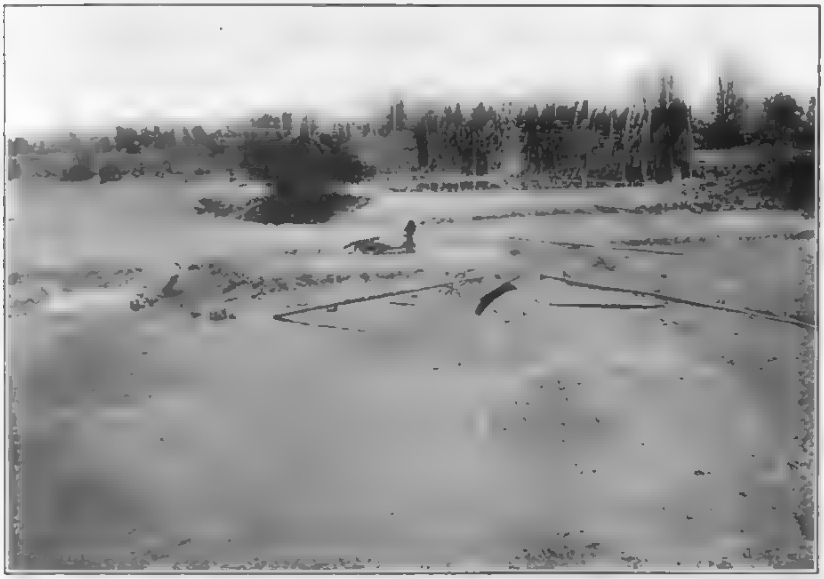

Fig. 1. Leaching vat and cement-lined receptacle into which the brine drains.

Fig. 2. Leaching vat from which leached mud has been removed.

PLATE IV.

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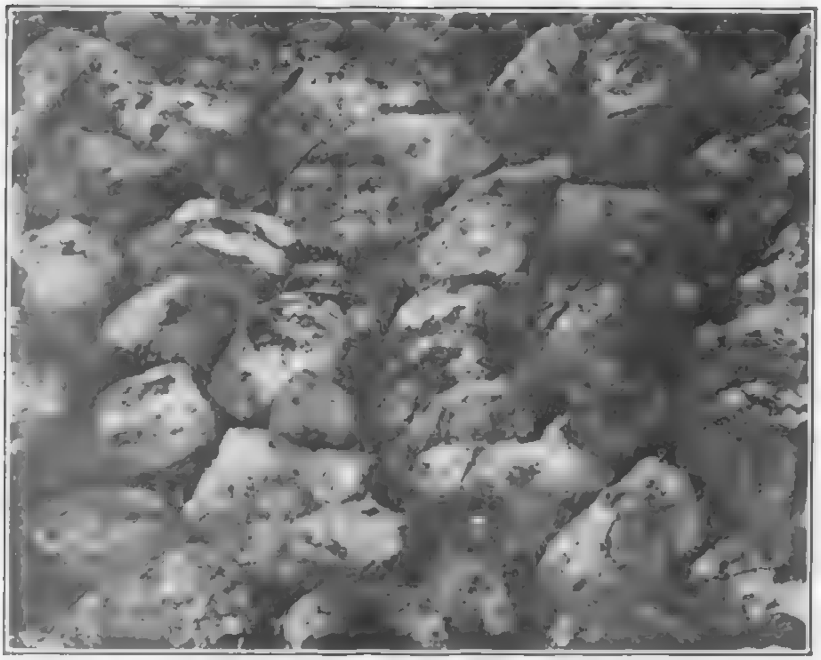

Fig. 1. Stones incrusted with salt.

Fig. 2. Washing the crust of salt from the stones.

PLATE XIV.

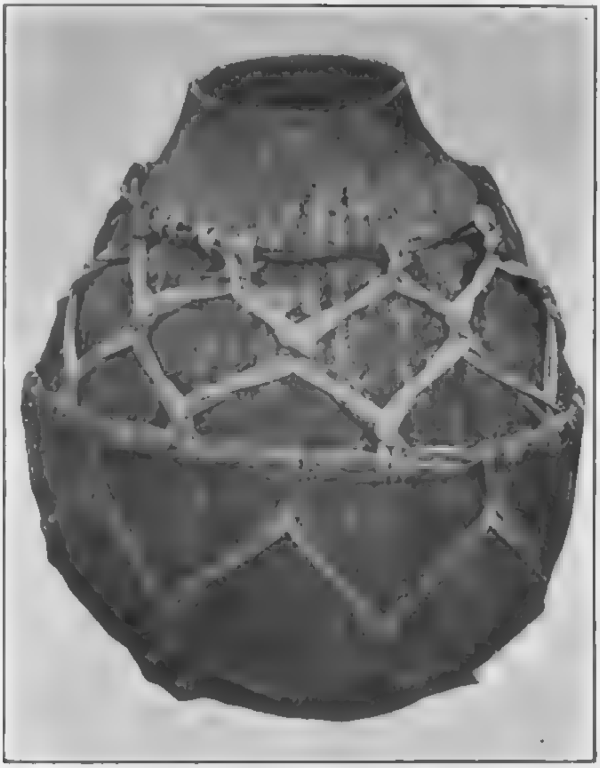

Fig. 1. Gourd for storing salt meats.

Fig. 2. Packages prepared for transportation.

PLATE XV.

PLATE XVI. SALT FURNACE AT AHIN.

Fig. 1. Near view of the Salinas salt springs.

Fig. 2. The lower end of the bamboo trough from the Salinas salt springs, showing the well from which the brine is carried to the evaporating pans.

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